Identifying criteria for determining whether a ship produces reduced quantities of waste and manages it in a sustainable and environmentally sound manner

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List of abbreviations

Acronym	Description
ADM	Administrative waste fee/contribution system
AWWTP	Advanced wastewater treatment plants
BATEA	Best Available Technology Economically Achievable
BCT	Best Conventional pollutant control Technology
BImSchV	Federal Emission Control Ordinance
BPT	Best practicable control technology currently available
CH_4	Methane
CO_2	Carbon dioxide
CRS	Cost Recovery System
CSI	Clean Shipping Index
DG Move	Directorate-General for Mobility and Transport
EC	European Commission
ECSA	European Community Shipowner's Associations
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
e-fuels	electro fuels
EGCS	Exhaust Gas Cleaning System
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EMSA	European Maritime Safety Agency
EPA	Environmental Protection Agency
EPF	European Port Forum
ESI	Environmental Shipping Index
ESPO	European Sea Ports Organization
EU	European Union
EU MRV	EU Monitoring, Reporting and Verification of CO_2 emissions
GMP	Garbage management plan
GT	Gross Tonnage
HELCOM	Helsinki Commission
HFO	Heavy Fuel Oil
IBTS	Integrated Bilge Water Treatment System
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
ISO	International Organization for Standardization
KPI	Key performance indicator
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MEPC	Marine Environmental Protection Committee
MGO	Marine Gas Oil
NCTI	Not common to install
NI	Not installed
NO_x	Nitrogen oxides
NPDES	National Pollutant Elimination System
NSF system	No Special Fee system
NU	Not used
OECD	Organization for Economic Co-operation and Development
OI	Commonly installed
OU	Frequently used
OWS	Oily water separator
Paris MoU	Paris Memorandum of Understanding
Pax	Passengers
PDCA	Plan, Do, Check, Act
PM	Particulate matter
ppm	Parts per million
PRF	Port Reception Facility
PSC	Port State Control
pts	points
Ro-Pax ships	Combined Roll on – Roll off & passenger ships
Ro-Ro ships	Roll on – Roll off ships
R&D	Research & Development
SEEMP	Ship Energy Efficiency Management Plan
SGW	Ship Generated Waste
SI	Sometimes installed
SO_x	Sulfur oxides
SU	Sometimes used
TRL	Technology Readiness Level
U.S.	United States
uv	Ultraviolet

Acronym	Description
uz110	Environmental-Conscious Ship Operation (environmental standard of Blue Angel eco-label)
uz141	Eco-friendly Ship Design (environmental standard of Blue Angel eco-label)
VGP	Vessel General Permit
WBS	White Box System
WRHP	Waste Reception and Handling Plan

Summary

Directive (EU) 2019/883 of the European Parliament and of the Council of 17 April 2019 on port reception facilities for the delivery of waste from ships, amending Directive 2010/65/EU and repealing Directive 2000/59/EC specifies, inter alia, that Member States must require that ships calling at their ports pay a fee to cover the costs of operating port reception facilities. However, the fee shall be reduced if, inter alia, 'the ship's design, equipment and operation demonstrate that the ship produces reduced quantities of waste, and manages its waste in a sustainable and environmentally sound manner' (Article 8(5)(b)).

This report identifies criteria to determine that a ship produces reduced quantities of waste and manages it in a sustainable and environmentally sound manner, in support of an implementing act to be adopted in accordance to Article 8(5)(b) of Directive 2019/883/EU.

To that end, a comprehensive literature review was conducted, stakeholders were surveyed, and interviews were held with a broad range of stakeholders.

Results show that common practices vary based on ship types and geographical areas of ports, and are linked to the type of offered ship services and the types and quantities of waste generated. Consequently, delivery of certain waste streams may be preferable in some ports, but not in others.

The criteria identified in Table 1 demonstrate how ships can engage in environment protection, going often further than what is legally required and beyond common practice. We therefore recommend the criteria listed in Table 1 to be included in the implementing act.

Table 1 - List of identified criteria for ports that can be applicable for a reduction in the delivery fees

Criteria	Basis	Related elements	Related to MARPOL	Verifiable
Existing equipment, systems and measures				
1. Use of alternative fuels and other energy sources	Reduction & Environmentally sound management (see Section 4.3)	Ship design, technology & Operation	Annex I	Through verification by Green Award, bunker delivery notes, oil record book.
2. Oily water separator (OWS) <5 ppm	Environmentally sound management (reduction of oil discharged at sea, see Section 4.4)	Technology & Operation	Annex I	Through verification by Green Award, CSI, NPDES, Blue Angel eco-label, Green Marine or Environmental Class Classification
3. OWS + alarm system and automatic stop for ships <10,000 GT	Environmentally sound management (reduction of oil discharged at sea, see Section 4.4)	Technology & Operation	Annex I	Through verification by Green Award, CSI, Green Marine, Blue Angel or Environmental Class Classification.
4. Sewage treatment system in compliance with IMO Res.MEPC.227(64) for cargo ships	Environmentally sound management (see Section 4.4)	Technology, Operation & Management	Annex IV	Through the sewage pollution prevention certificate verification by vessel classification and Green Award.
5. On-board segregation and ensured delivery in ports	Environmentally sound management (see Section 4.5)	Operation & Management	Annex V	Through verification by Green Award, ISO 21070, Blue Angel or Green Marine.

Criteria	Basis	Related elements	Related to MARPOL	Verifiable
6. Sustainable purchasing policies (reduction of packaging materials such as bulk packaging & avoiding single use plastic)	Reduction (see Section 4.5)	Management	Annex V	Through verification by Green Award, Blue Angel, ISO 21070 or Green Marine.
7. On-board reuse and recycling	Reduction & Environmentally sound management (see Section 4.5)	Operation & Management	Annex V	Through verification by ISO 21070 or Green Marine.
New equipment				
8. Integrated hydro-pyrolysis	Environmentally sound management (see Section 2.3.3)	Technology, Operation & Management	Annex I & V	New technology and therefore still need to be added to environmental management systems.
9. Waste gasification system	Environmentally sound management (see Section 2.3.3)	Technology, Operation & Management	Annex I & V	New technology and therefore still need to be added to environmental management systems.

Table 2 provides additional criteria that are less relevant when used as stand-alone criteria, as they only have a minor or an indirect contribution to the amount of waste, but which gain importance when combined with the criteria mentioned in Table 1.

Table 2 - Additional identified criteria for ports to reduce the delivery fees

Criteria	Basis	Related elements	Related to MARPOL	Verifiable
Use of onshore power supply	Reduction (see Section 4.3)	Ship design, Technology & Operation	Annex I	Verification through the use at ports.
Monitoring system for waste production	Environmentally sound management (creating insight, see Section 3.1)	Technology & Management	Annex I, V, VI	Through verification by ISO 21070 or Green Marine.
Recycling Key Performance Indicators (KPIs)	Environmental sound management (see Section 4.5)	Operation & Management	Annex V	Through verification by Green Marine
Creating crew awareness	Environmentally sound management (see Section 3.1)	Management	All Annexes	Through verification by Green Award, CSI or Green Marine.
Extensive data record keeping	Environmentally sound management (creating insight, see Section 3.1)	Operation & Management	All Annexes	Through verification by ISO 21070 or Green Marine.
Certified waste management index	Environmentally sound management (see Section 3.2)	Management	All Annexes	Through verification by all certified environmental management systems.

Some identified criteria regarding equipment and design should be placed in a broader context, such as the use of alternative fuels. E.g. the reduction of waste related to the production of sludge should be seen as a co-benefit of the main objective of reducing greenhouse gas and air emissions. For other criteria, it could mean that the verifiability is difficult since the reduction of waste is dependent on the individual trip.

1. Introduction

1.1. Policy background

The European Union maritime waste policy is based on the principles of preventive action to be implemented at the source, on the 'polluter pays' principle and on the principles of waste hierarchy in accordance with Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues was adopted in 2000. The aim of Directive 2000/59/EC was to reduce illegal discharges from ships using ports in the EU, by improving the availability and use of port reception facilities for ship-generated waste and cargo residues, thereby enhancing the protection of the marine environment.

Directive 2000/59/EC required Member States to ensure that the costs of port reception facilities for ship-generated waste, including the treatment and disposal of the waste, were covered through the collection of a fee from ships. The Ex-post evaluation (Panteia ; PWC, 2015) of Directive 2000/59/EC demonstrated a large variety of cost recovery systems had been implemented by ports to charge port users for the delivery of waste to port reception facilities and that a majority of EU ports had implemented a variation of the indirect fee. The evaluation showed that in most cases, the indirect fee system was applicable to oily waste and garbage (MARPOL Annex I and V), and in a few cases, sewage and non-hazardous cargo residues were included as well (MARPOL Annex IV and V).

The evaluation demonstrated the Directive's contribution to the increased volumes of waste (MARPOL Annex V) being delivered to port reception facilities by ensuring that ships contribute to the costs of those facilities, irrespective of their actual use of those facilities. The evaluation also showed a need for more harmonization with the MARPOL Convention due to the important amendments that took place in the last two decades.

In 2018 Directive 2000/59/EC was revised, which led to the adoption of a new Directive 2019/883/EU (PRF Directive) that was adopted by the European Parliament and the Council on 17 April 2019, repealing the Directive 2000/59/EC.

The PRF Directive entered into force on 27 June 2019 and has to be transposed by EU Member States by 28 June 2021.

As the old Directive 2000/59/EC, Directive 2019/883/EU specifies, inter alia, that Member States must require that ships calling at their ports pay a fee to cover the costs of operating port reception facilities. However, the fee will be reduced if, inter alia, 'the ship's design, equipment and operation demonstrate that the ship produces reduced quantities of waste, and manages its waste in a sustainable and environmentally sound manner' (Article 8(5)(b)).

1.2. Regulatory framework

1.2.1. IMO Legislation

The international regulatory framework for the shipping industry regarding the on-board management of ship-generated waste and the protection of the marine environment is established by the International Maritime Organization (IMO). The International Convention for the Prevention of Pollution from Ships (MARPOL Convention), together with its six Annexes, provides general prohibitions on discharges into the marine environment, but also regulates the conditions under which certain types of waste can be discharged into the sea. Specific equipment requirements, for the ship on-board waste handling, are also addressed by the MARPOL Conventions[1].
The MARPOL Convention further requires contracting Parties to ensure the provision of adequate reception facilities in ports and imposes mandatory equipment requirements for ships. In addition to the MARPOL Convention (including its Annexes) the IMO has adopted guidelines in relation to the management of ship-generated waste.

Certain handling practices established in the PRF Directive are encouraged through IMO guidelines but are not required by the MARPOL Convention. They include:

- guarantee of separate collection;
- relation to Directive 2008/98/EC regarding waste hierarchy and downstream treatment;
- port waste reception and handling plans;
- mandatory delivery of waste, except for some MARPOL Annex II wastes;
- waste notifications and waste receipt;
- cost recovery system;
- enforcement scheme.

1.2.2. European Legislation

Directive 2019/883/EU sets out requirements regarding:

- inclusion of all wastes within the scope of Annexes I, II, IV, V and VI of the MARPOL Convention, including cargo residues in the definition of ship generated waste, and including also passively fished waste;
- inclusion of fishing vessel and recreational craft in the cost recovery system;
- guarantee of separate collection (Article 4 paragraph 2);
- consultations for the preparation of the waste reception and handling plans (WRHP, Article 5);
- electronically report of the advanced waste notification (Article 6);
- cost recovery system (CRS, Article 8);
- electronically report of the waste receipts (Article 13);
- availability and update of waste reception and handling plans electronically through SafeSeaNet (Article 13);
- identification of categories of costs and net revenues to the operation and the administration of PRF (direct costs, indirect costs and net revenues, annex 4).

[1] These requirements are addressed in Section 2.1.

Cost recovery system (CRS)

According to Directive (EU) 2019/883, the chosen CRS of ports will provide no incentive for ships to discharge their waste at sea. One way to ensure delivery of waste to PRF instead of discharge at sea is that all ships should contribute significantly to the costs, irrespective of the actual use of the facilities. A specific change to Article 8 is the inclusion of an indirect fee, which means a fee paid for the provision of port reception facility services, irrespective of the actual delivery of waste from ships. Directive 2000/59/EC had the same implication, but there was no mention of the term "indirect fee" and there was no indication of the amount the covered fee should represent. Even though the term "indirect fee" was not mentioned in the former directive, it was a common practice at ports and administrations to use this term.

The current applied CRS system, which is still based on the repealed PRF Directive, allows several fee systems to co-exist within a port, choosing the system that best represents the ports policies. Most of the EU ports have implemented a form of an indirect fee system.
In previous assessments of the repealed PRF Directive the indirect fee is referred to as the "no special fee (NSF) system" (EMSA, 2010).

The amount of indirect fee per ship is usually based on the ship size and in some cases on ship type or traffic route. In most cases parts of waste from MARPOL Annex I (liquid oily waste) and Annex V (non-hazardous garbage) are included in the indirect fee system. Indirect fees are usually combined with the requirement of reasonable quantities, meaning that a specified quantity is covered and all that exceeds this quantity will be charged by other systems, usually a direct fee. In special area's where discharge of sewage (MARPOL, Annex IV) is limited or prohibited, this waste is also covered by the indirect fee.
One of the most significant changes to the cost recovery system is that in order to provide a maximum incentive for the delivery of MARPOL Annex V waste (other than cargo residues) no direct fee will be charged (i.e. it should be covered through a 100% indirect fee system for ship generated garbage, except when the volume exceeds the maximum storage capacity of a ship). This will have a significant impact on the way ports calculate their indirect fee. Most ports cover the costs of garbage in their indirect fee, but have limitations regarding the volume that can be discharged within the indirect fee coverage.

Other amendments on the cost recovery system are found in Table 14 in Annex A.

In accordance with the PRF Directive, Article 8(5)(b), the fees will be reduced if "the ship's design, equipment and operation demonstrate that the ship produces reduced quantities of waste, and manages its waste in a sustainable and environmentally sound manner". In some ports, the delivery fees are reduced as part of an environmental scheme or index, such as the Environmental Shipping Index (ESI) the Green Award and the Clean Shipping Index (CSI). Some of these schemes have criteria which include waste elements[2]. Specific criteria for reducing waste delivery fees, based on categorization of the ship's efforts (directly or indirectly) to reduce their amount of wastes produced and managing its waste in an environmentally sound manner, was until now not yet investigated.

The PRF Directive further establishes that the Commission will adopt implementing acts to define the criteria for determining that a ship meets the requirements.

[2] The results of the inventory of schemes, with specific waste elements, which are awarded with a fee reduction is given in Sections 3.2 and 3.3.

1.3. Objective

The purpose of the study is to identify criteria for determining that a ship meets the requirements for design, equipment and operation in order to demonstrate that the ship produces reduced quantities of waste, and manages its waste in a sustainable and environmentally sound manner in support of an implementing act to be adopted in accordance to Article 8(5)(b) of Directive 2019/883/EU. The objective is to identify a set of criteria as a base for a waste delivery fee reduction provided by ports/administrations or other entities responsible for collecting a waste delivery fee from ships.

One of the main factors in order to identify such criteria, is to develop standards that are recognized by stakeholders, that are considered to be fair and not distorting a level playing field. An important factor during the identification process, is that the possible obtained reduction in waste delivery fees based on the new set rules does not provide an incentive for ships to discharge their waste at sea.

Other factors that are important for identification of such criteria are:

- The determination of a minimum baseline based on the 'level of compliance' with MARPOL and its annexes.
- Consideration of factors that show that measures are taken to reduce waste at the source and management of waste in an environmentally sound manner, such as criteria that are identified in international standards and environmental management systems.
- To follow the basic principles of waste hierarchy as dictated in Directive 2008/98/EC on waste i.e. prevention, reuse, recycling, energy recovery and disposal, taking into account that external recycling can only be practiced after separated collection on-board and disposal to the PRF.
- the difference in ships types, taking into account limitations on-board regarding space and system of handling waste.

1.4. Scope of the project

For reasons of keeping a level playing field the identification of the criteria will be developed so that all ship types can, in principle, benefit from a reduction of waste fees.

All types of waste as defined in Directive 2019/883/EU will be included in this study i.e. waste of MARPOL, Annexes I, II, IV, V and VI, except for cargo residues (Article 8(1)). According to recital 34 of the new PRF Directive "Cargo residues remain the property of the cargo owner after unloading the cargo to the terminal, and may have an economic value. For this reason, cargo residues should not be included in the cost recovery system and the application of the indirect fee".

More specifically, this study will take into account all measures taken by ships to reduce the quantity of produced waste, such as prevention, minimization, reuse, recycling, processing and recovery and measures that show that the ship manages its waste in an environmentally sound manner.

The waste hierarchy as described in Directive 2008/98/EC will be taken into account as well as the actions regarding environmentally sound waste management i.e. that waste management is carried out without endangering human health, without harming the environment and, in particular without risk to water, air, soil, plants or animals. The working definition used by the Organization for Economic Co-operation and Development (OECD) for environmentally sound management of waste is defined as "a scheme for ensuring that wastes are managed in a manner that will save natural resources, and protect human health and the environment against adverse effects that may result from such wastes and materials" (OECD, 2007).

The aim of the waste policy of Directive 2008/98/EC is to reduce the use of resources, and favor the practical application of the waste hierarchy. For this study, waste reduction is applied as reduction at the source. According to the Maritime Environmental Protection Committee of the IMO waste minimization is described as prevention at the source and that "shipowners should minimize taking on-board material that could become garbage" (MEPC.219(63). In accordance to the United States Environmental Protection Agency (EPA) definition of the term minimization, which is not described in the waste hierarchy, can be defined as "means to reduce and/or eliminate to the extent achievable using control measures (including best management practices) that are technologically available and economically practicable and achievable in light of best marine practice" (EPA, 2013).

Measures must be taken into account for the following waste types:

- oily bilge water and oily residues, such as sludge (MARPOL, Annex I);
- residue/water mixtures of noxious liquid substances (e.g. tank cleaning and slops MARPOL, Annex II);
- sewage (MARPOL, Annex IV);
- garbage (MARPOL, Annex V);
- air Pollution related waste (MARPOL, Annex VI).

In some cases, discharge into the sea is allowed given certain provisions of MARPOL Annexes I, II, IV, V and VI. It is important for the identification of criteria to focus on the equipment, management and operational systems that ensures a reduction of these wastes and/or that these wastes are managed in an environmentally sound manner. Examples are cleaner technologies to reduce the amount of these wastes legally discharged to the marine environment, better procedures for processing these wastes, maintenance of the technical equipment and the involvement of personnel.

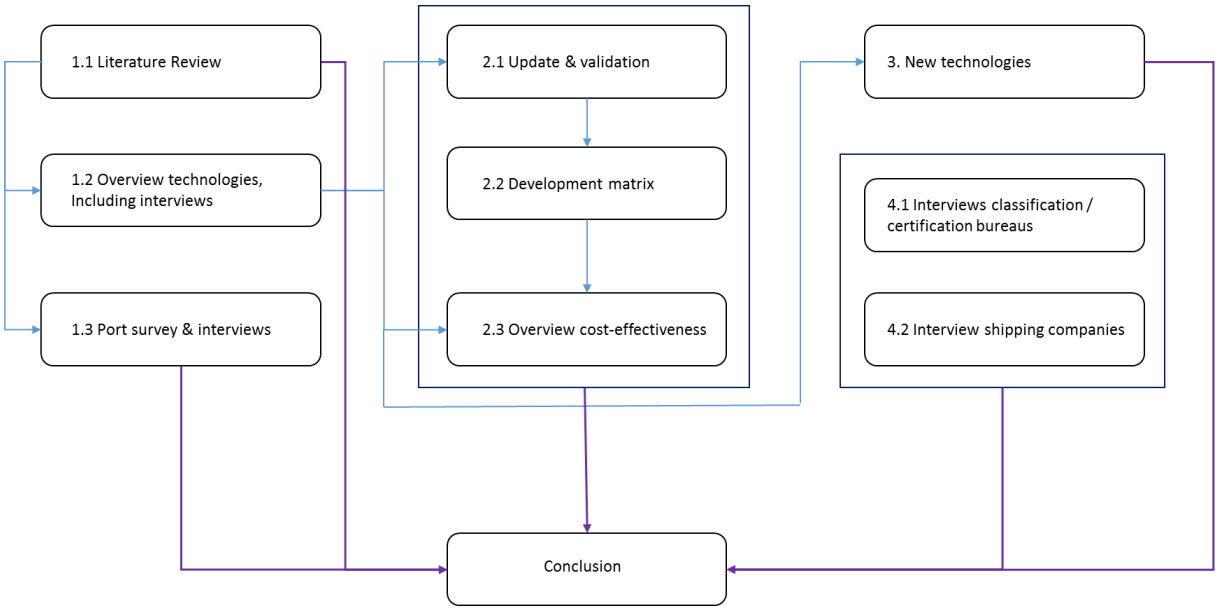
1.5. Research methodology

The process for identification of criteria in the context of this study is achieved through the following steps:

1. To provide an overview of the present context of the ship design and equipment that are directly related to reduced production of waste and attribute to on-board waste management (Task 1).
2. To produce an inventory of available technologies in the market as well prototypes that directly or indirectly reduce waste and/or improve on-board waste management (Task 2 and 3).
3. To identify relevant operational practices and environmental management systems which results in reduced waste production and improve waste management on-board (Task 4).

The results were gained through literature review, targeted stakeholder consultation, interviews and an internet survey among shipowners and ports. The methodology approach is illustrated in Figure 1.

Figure 1 - Methodology approach



Literature review

The purpose of this task is to provide an overview of the present context based on the legal framework, the available technologies and existing initiatives of already established 'criteria' that form a baseline for further identification. An overview of the literature reviews is presented in Annex B. The literature review provided a base for the following tasks:

- overview of the present technologies used (Task 1.2);
- development of the questionnaire for the targeted stakeholder consultation (all tasks);
- development of the questionnaire for the internet surveys for shipowners and ports (Task 1.2 and 1.3).

Targeted stakeholder consultation (interviews)

The purpose of the stakeholder consultation is to:

- update the relevant technologies and equipment available (Task 1);
- identify sustainable factors used by ports and administrations to provide incentives to ships (Task 1.3);
- get an overview of relevant 'new' technology/equipment available and or in development (Task 3);
- identify best operational practices and management systems that result in waste reduction (Task 4.1 and 4.2).

Several stakeholders were identified with importance to this process and were categorized as followed:

- shipowners/shipping companies;
- European ports;
- experts, consisting of shipbuilders, waste collectors and administrations (inspection agencies);
- marine equipment providers;
- certification agencies.

A specific questionnaire was developed for each different category of stakeholder, as presented in Annex **Error! Reference source not found.** A total of 18 interviews were conducted with ports, administrations, shipping companies, waste collectors, yards, marine equipment providers, certification bureau's and inspectors to obtain an overview of the current situation. Three statements were received from European stakeholders' associations.

Internet survey among ports and shipowners/shipping companies

The internet survey for shipowners and European ports was conducted between July and September 2020. The questionnaire for ports and shipping companies was used and specified to fit the survey tool. The surveys were distributed to ports and shipping companies via the European Sea Ports Organization (ESPO), the European Community Shipowners' Associations (ECSA) and the European Port Forum (EPF). 20 ports and 21 shipping companies completed the surveys. The shipping companies that participated in this study represent 594 ships in total.

1.6. Reading guide

The first chapters of this report reflect the results of the desk research, interviews and response of the surveys. Chapter 1 provides the political background, regulatory framework and the methodology for this study. Chapter 2 provides an overview of the current used technology and equipment by several types of ships, with relevance to their waste production and handling on-board ships. It also gives the mandatory requirements for design and equipment and provides an overview of new technologies. Chapter 3 provides an inventory of operational practices and voluntary environmental management systems. It also gives an overview of the current reductions on the waste delivery fee by ports and administrations. In Chapter 4 the conditions for identification of criteria are addressed and the elements for reduction and environmentally sound management measures are ranked by both ports and shipping companies. Furthermore, an analysis is provided for the top 10 ranked measures based on the waste hierarchy and views of the stakeholders provided during the interviews and survey. In Chapter 5 a list of principles and steps for the identification of criteria is provided and the identified criteria is presented.

2. Overview of ship and equipment

In this chapter, we map out the current situation with regard to regulatory framework and technologies and equipment used to reduce ship generated waste. An overview of the current regulatory framework is described in Section 2.1, with focus on the MARPOL regulations and the requirements for ship design in relation to efficiency. Section 2.2 provides an overview of the European and global fleet and an overview of the current technologies and available equipment on-board of ships related to waste reduction or minimization. A technology matrix is included which indicates which ship types make use of certain type of waste reduction and/or minimization technologies. In addition, new technologies are described. Section 2.4 provides a preliminary conclusion about the used and new technologies as potential basis for criteria for determining whether a ship produces reduced quantities of waste and manages its waste in a sustainable and environmentally sound manner.

The necessary information for this chapter is obtained through interviews and surveys.

2.1 Technical requirements based on the MARPOL Convention

The focus of the PRF Directive is on improving the availability and use of adequate reception facilities in ports and the delivery of waste to those facilities. The focus of the MARPOL convention is on the waste handling on-board ships as well as aspects regarding on-board treatment and requirements for legal discharge at sea. The PRF Directive therefore does not contain specific equipment requirements for the on-board handling of waste. For the purpose of setting a base line for identification of criteria for equipment that demonstrates that a ship produces reduced amounts of waste an overview of MARPOL Convention technical requirements is set out in Table 17 in Annex E.

The table provides mandatory requirements per MARPOL Annex. The equipment requirements on-board ships are few and depend on size and type of a ship and in some cases on the certified number of persons on-board. For legal discharge at sea, ships may need to obtain equipment that are required for this purpose only, such as a grinder or comminutor for the discharge of food wastes of not larger than 25 mm.

For liquid oily waste for example, Annex I describes which ship type and sizes needs to be equipped with oil filtering equipment including corresponding requirements to this equipment. All ships above 400 GT are required to have oil filtering equipment and a sludge or holding tank with sufficient capacity. The discharge criteria for oil mixtures passing the oil filter equipment is an oil content that does not exceed 15 ppm. Ships above 10,000 GT are required to have in addition to the oil filtering equipment an alarm and automatic stopping device.

For sewage (Annex IV) all ships above 400 GT or certified to carry more than 15 persons on-board need to be equipped with either an approved:

- holding tank (and may discharge moderately when the ship is >12 nautical miles from nearest land sailing on route at not less than 4 knots);
- sewage comminuting and disinfecting system (and may discharge >3 nautical miles from nearest land); or
- a sewage treatment system (and may discharge <3 nautical miles from nearest land).

Furthermore, within special areas appointed by MARPOL Annex IV, such as the Baltic Sea, discharge of sewage at sea after treatment is prohibited for newly build passenger ships after June 2019 and for existing passenger ships after June 2021. The stricter discharge limits for the special area can be achieved with the installation of advanced wastewater treatment plants (AWWTP). The discharge limits for these plants are similar to those for land-based municipal treatment plants and significantly reduce the nutrient input.

Most of the equipment used on-board for waste management and or treatment on-board are thus not required. In the case a ship, based on its operations and route, decide to install certain type of equipment for waste management, it is possible that the equipment has to be approved by the administration. This is the case with, for example, incinerators, sewage treatment plants and oil filtering and monitoring equipment.

Besides the mandatory equipment requirements, ships need to adhere to discharge standards and limits for different types of waste and need to have mandatory record and management books on-board such as the garbage record book for ships above 400 GT (Annex V) and the oil record book (Annex I). All ships above 100 GT are required to have a garbage management plan with written procedures for minimizing, collecting, storing, processing and disposing of garbage, including the use of equipment on-board.

2.2 Technical requirements for ship design and operation

In 2013, the Energy Efficiency Design Index (EEDI) was made mandatory for new newly build ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships at MEPC 62 with the adoption of amendments to MARPOL Annex VI (resolution MEPC.203(62)).

The Energy Efficiency Design Index (EEDI) sets a standard for energy efficiency of new ships per capacity mile (e.g. grams CO_2/tonne mile). On average, ships with a more efficient design also have a better operational efficiency, but it is important to keep in mind that this does not always have to be the case.

The Ship Energy Efficiency Management Plan (SEEMP) is an operational measure which provides an approach for shipping companies to manage ship and fleet efficiency performance over time using, for example the Energy Efficiency Operational Indicator (EEOI) as a monitoring tool.

Even though there are requirements for the efficiency of ships, the EEDI and SEEMP leaves the choice of technologies to use in a specific ship to the industry. IMO provides through the Global Maritime Energy Efficiency Partnerships, a portal for technologies for energy efficiency, where ship owners and designer can choose from (GLOMEEP, ongoing).

2.3 Overview of used and new technologies and equipment

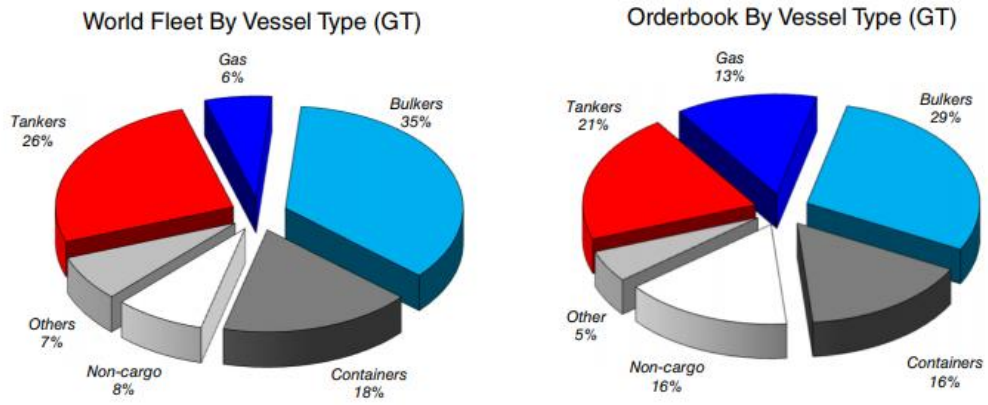
This section provides an overview of the world and European fleet by vessel type and an overview of the current technologies and available equipment on-board of ships related to waste reduction or minimization. The overview has been compiled for this project on the basis of a survey and a series of interviews.

The shipping companies who participated in the interviews and/or surveys represent in total 594 ships and a wide range of ship sizes in the category dry bulk carriers, tankers, container ships, Ro-Ro ships, general cargo ships, ferries, Ro-Pax ships, fishing vessels and cruise ships. Most of the shipping companies who participated in this study are located in Europe, but their ships are operating both in Europe and worldwide.

2.3.1 Overview of the world and European fleet

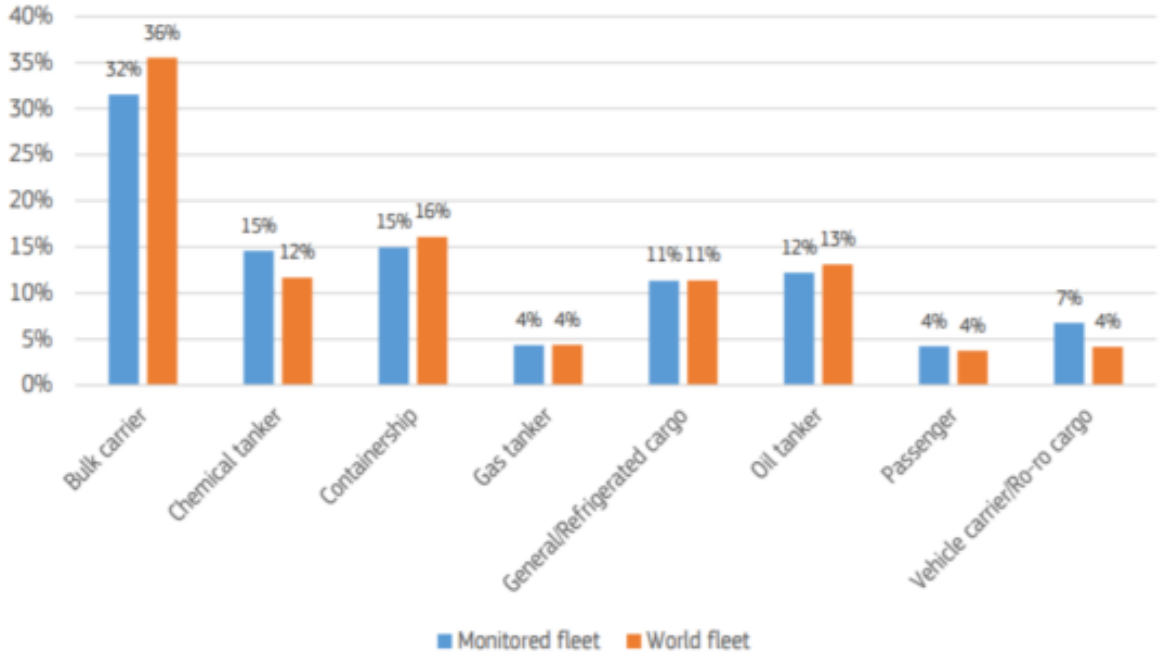
Figure 2 shows both the world fleet and the order book by ship type (in GT) (Clarksons Research Portal, 2020). Bulkers, tankers (oil & chemicals) and container ships are the top 3 ship types in the world. The order book is almost equal to the world fleet which indicates that this top 3 ship types will not change the coming period.

Figure 2 - World fleet by ship type (in GT)



The distribution of number of ships by ship type in the European monitored fleets and the world fleets (over 5,000 GT) is shown in **Figure 3** (EC, 2020). The European monitored fleet is based on the EU MRV (Regulation (EU) 2015/757) data from 2019. From the figure can be concluded that the European fleet structure is similar to the world fleet structure.

Figure 3 - The distribution of number of ships by ship type in the European monitored fleets and world fleets (over 5,000 GT)



Almost all relevant ship types and sizes were represented in the interviews and survey. The sample size was not sufficient to ensure statistical representativeness, but the variety amongst respondents in terms of fleet size, ship type, and location makes it likely that the most common technologies are captured. It should also be noted that particular ship types produce higher amounts of particular types of waste. A passenger ship produces for example more garbage and sewage compared to a cargo ship such as a bulk carrier.

2.3.2 Overview of current used technologies to reduce waste

The minimum requirements for technology on-board ships in relation to waste handling and treatment is provided by the MARPOL regulation as described in Section 2.1 and Annex E.
An overview of the technologies installed on-board of ships to reduce, treat and/or minimize waste is provided in Table 3. It also indicates for which type of waste the technology/equipment is intended and it shows if the technologies are mandatory according the MARPOL regulations or if the technologies are additional measures above the minimum required baseline.

The technologies and systems which are described are based on the information received from interviews and surveys with the shipping companies.

Table 3 - Description of current waste handling equipment on-board of ships of companies that participated in the survey and interviews

Technology/System	Intended for waste related to MARPOL	Degree of obligation based on MARPOL	Description
Oily water separator	Annex I	Required for ships >400 GT >10,000 GT (including an alarm and automatic stop)	An oily water separator (OWS) is a piece of equipment specific to the shipping or marine industry which is used to separate oil and water mixtures into separate components. The OWS is used to separate oil from oily wastewater such as bilge water before the wastewater is discharged at sea. The wastewater which will be discharged at sea can have a maximum oil content of 15 ppm according the MARPOL regulations.
White Box System or other similar systems	Annex I	Additional system, not required	The White Box System is a piece of equipment which can be additionally used after treatment by an oily water separator. The White Box System is a fail-safe system to discharge bilge water with higher oil content than required overboard. The oil content of the pumping water is adjustable between 15 ppm and 5 ppm.
Incinerator	Annex I & Annex V	Additional system, not required	An incinerator minimizes waste by incineration, leaving ashes as a residual product. Waste with a high oil content, paper and cardboards can be incinerated depending on the type of the incinerator.
Pump and pipe system (for tankers with max. 75 liter of residues)	Annex II	Required for ships constructed on or after 1 July 1986	A pumping and piping arrangement which ensure that each tank certified for the carriage of substances in the category X, Y or Z does not retain a quantity of residue in excess of 75 liters in the tank and the associated pipelines (MARPOL, 2020).
Sewage treatment system, comminuting and disinfection system or a holding tank	Annex IV	Required for ships above >400 GT or certified to carry >15 persons	The basic principle of a sewage treatment system is the decomposition of raw sewage by aerating the sewage chamber with fresh air. The aerobic bacteria survive on this fresh air and decompose the raw sewage which can be discharged at sea in selected areas.
Biological physical treatment of sewage	Annex IV	Not required in case a holding tank is installed	Physical treatment of sewage by filtration and sedimentation. Floating and suspended matter will be removed by filtration. The filtrate will be stored in settling tanks where grit will settle down as sludge. Biological treatment is based on bacteria or other

Technology/System	Intended for waste related to MARPOL	Degree of obligation based on MARPOL	Description
			small organism to break down the sewage into effluent and sludge
Sewage advanced ozone reactors	Annex IV	Not required in case a holding tank is installed	Advanced ozone reactors use ultraviolet (uv) with advanced oxidation to treat sewage and ensure that grey water can be reused. The system creates a smaller footprint compared to biological treatment.
Compactors	Annex V	Additional system, not required	Compactors compress waste in order to reduce the volume of the waste. Compactors are most efficiently applied on high-volume, low density materials such as plastics, light metals and paper.
Crushers	Annex V	Additional system, not required	Crushers are machines which are used to crush and compact glass.
Shredders	Annex V	Additional system, not required	Galley waste and shipboard shredders use rotating blades to minimize waste volumes.
Comminuters	Annex V	Additional system, not required	Comminuters are large garbage disposal systems which grind food scraps into a find residual and rinse out that residual with a steady stream of water. These food discharges are allowed to discharge at sea as from a certain distance from the shore.
Grinders/food pulpers	Annex V	Additional system, not required	Grinders/food pulpers are used to shred food scraps which thereafter can be stored on-board or discharged at sea.
Pulpers	Annex V	Additional system, not required	Pulpers reduce paper and cardboard to papier-mâché which can be discharged at sea.
Closed loop exhaust gas cleaning system	Annex VI	Additional system, not required	Exhaust gas cleaning systems remove sulphur oxides from the exhaust gases. Closed loop exhaust gas cleaning systems use fresh water to scrub the exhaust gases. The waste water (a combination of fresh water and sulphur oxides) is treated and stored on board and must be disposed ashore (CE Delft, 2020).

A further specification is made in Table 5 which provides a technology matrix to indicate what kind of technologies/equipment is used on which type of vessel. The table is created based on the input received from the surveys and interviews. The surveys and interviews showed that the ship type in particular has a major influence on the installed systems. The age of the ships also has an impact. The newer the ships, the more advanced systems are installed. For smaller ship sizes <400 GT, such as fishing ships, it is not common to install advanced systems.

As earlier mentioned, the shipping companies who participated in the interviews and/or survey have all relevant ships such as dry bulk carriers, tankers, container ships, Ro-Ro ships, general cargo ships, ferries, Ro-Pax ships, fishing vessels and cruise ships in their fleet. Despite the fact that all relevant ship types are represented, not all ship types are represented to the same degree. More shipping companies participated in this study concerning tankers, container ships, Ro-Ro ships, dry bulk carriers and general cargo ships in comparison to ferries, cruise ships and fishing vessels. This reflects the differences in the composition of the European and global fleet distribution as mentioned in **Figure 3**.

Table 4 shows the index belonging to the technology matrix which is provided in Table 4. The index shows six different color codes:

1. "Commonly installed" means that more than 60% of the shipping companies who participated to this study and which have a certain ship type in their fleet have installed the system on their ships of this ship type.
2. "Frequently used" means that more than 60% of the systems which are installed on a certain ship type are actually in use.
3. "Occasionally installed" means that less than 60% of the shipping companies who participated to this study and which have a certain ship type in their fleet have installed the system on their ships of this ship type.
4. "Occasionally used" means that less than 60% of the systems which are installed on a certain ship type are actually in use.
5. "Not installed" means that no shipping company who participated to this study and which have a certain ship type in their fleet have installed the system on their ships of this ship type.
6. "Not commonly installed" is only used for technologies on fishing vessels. Too few correspondents related to fishing vessels participated in this study to draw correct conclusions. However, their statements and comments showed that it is not common to install certain technologies.
7. "Not used" speaks for itself and means that the system is not in use.

The technology matrix is purely based on the input received from the surveys and interviews which makes it possible that some ships of a certain ship type that did not participate in this study have installed specific systems on-board.

Table 4 - Index for technology matrix in Table 4

Colour	Description
CI – FU	Commonly installed and frequently used
CI – OU	Commonly installed, but occasionally used
OI – FU	Occasionally installed and frequently used
OI – OU	Occasionally installed and occasionally used
NI- NU	Not installed and not used
NCI	Not commonly installed

Table 5 - Technology matrix based on the input from the shipping companies who participated in the surveys and interviews

Technologies	Intended for waste related to MARPOL	Dry bulk carriers	Tankers	Container and RoRo ships	General cargo ships	Ferry and Ro-Pax ships	Fishing vessels	Cruise ships	Other
Oily water separator	Annex I	CI-FU	CI-FU	CI-FU	CI-FU	CI-FU	NCI	CI-FU	CI-FU
White Box System or other similar systems	Annex I	NI - NU	OI - FU	OI - OU	NI - NU	OI - FU	NCI	CI-FU	OI - OU
Incinerator	Annex I & V	OI - FU	CI-FU	OI - FU	OI - FU	NI - NU	NCI	CI-FU	OI - OU
Pump and pipe system (for tankers) with max. 75 l of residues	Annex II	NI - NU	OI - FU	NI - NU	NI - NU	NI - NU	NI - NU	NI - NU	NI - NU
Sewage treatment system	Annex IV	CI-FU	CI-FU	CI-FU	CI-FU	CI-FU	NCI	CI-FU	CI-FU

Technologies	Intended for waste related to MARPOL	Dry bulk carriers	Tankers	Container and RoRo ships	General cargo ships	Ferry and Ro-Pax ships	Fishing vessels	Cruise ships	Other
Biological physical treatment of sewage	Annex IV	OI - FU	OI - FU	CI-FU	NI - NU	NI - NU	NCI	CI-FU	OI - FU
Sewage advanced ozone reactors	Annex IV	NI - NU	NI - NU	NI - NU	NI - NU	NI - NU	NCI	OI - FU	NI - NU
Compactors	Annex V	CI - OU	OI - FU	CI - OU	OI - FU	OI - FU	NCI	CI-FU	OI - FU
Crushers	Annex V	NI - NU	OI - FU	OI - FU	OI - FU	CI-FU	NCI	CI-FU	NI - NU
Shredders	Annex V	NI - NU	OI - FU	OI - FU	OI - FU	OI - FU	NCI	CI-FU	OI - FU
Comminuters	Annex V	OI - FU	OI - FU	OI - OU	OI - OU	NI - NU	NCI	CI-FU	NI - NU
Grinders/food pulpers	Annex V	OI - OU	OI - FU	OI - OU	OI - FU	NI - NU	NCI	CI-FU	OI - FU
Pulpers	Annex V	NI - NU	NI - NU	NI - NU	OI - FU	NI - NU	NCI	CI-FU	NI - NU
Open loop exhaust gas cleaning system	Annex VI	NI - NU	OI - FU	OI - FU	OI - FU	OI - FU	NCI	CI-FU	NI - NU
Closed loop/hybrid exhaust gas cleaning system	Annex VI	NI - NU	OI - FU	OI - FU	OI - FU	OI - FU	NCI	NI - NU	NI - NU

Note: 'Other' includes offshore support vessels, ice breakers and training ships. These ship types are not reportedseparately because there are few ships of each type in our sample.

The technology matrix shows that an oily water separator and sewage treatment systems are commonly installed and used by all ship types as expected since these are the minimum baseline requirements for all ships above 400 GT. The type of sewage treatment differs, container/ro-ro and cruise ships often use the biological sewage treatment system. The Ozone reactors are less installed as a sewage treatment system.

Incinerators are commonly installed on ships which are involved in long trade routes and on vessels with a high amount of waste related to MARPOL Annex I and Annex V. Even though an incinerator is optional, when installed it should meet the MARPOL requirements as described in Annex VI, regulation 16.

Fishing vessels are not comparable with cargo or passenger ships and are diverse. Their length overall varies from a few meters to more than a hundred meters. As a result, there is much variation in the number of crew, the amount of fishing gears, the type of fishing operation, trip length (varying from a few hours to several weeks), the engine type and size. All these variables have a relation to waste generation and waste management. In addition to this, the port conditions where these types of vessels operate are very varied. There are one-quay ports without any other facility, bigger harbors with several facilities and everything in between. In addition, fishing vessels are sometimes owned by big international companies and other times by individual shipowners. The big differences between fishing vessels and other ship types therefore means that most systems listed in **Table 5** are not commonly installed on fishing vessels. However, this does not mean that the systems are never installed.

Table 5 shows that cruise ships tend to have more waste handling equipment than other ship types, which is in line with the importance of waste handling for these type of ships in relation to the amount of waste produced due to crew and passengers.

In relation to MARPOL Annex V waste, ferries and Ro-Pax ships on the contrary have less equipment installed on-board. This can be explained by the short voyages and frequent port visits which gives the possibility to dispose their waste daily to contractors. Other types of vessels such as dry bulk carriers, tankers, container and RoRo ships and general cargo ships have few systems installed related to MARPOL Annex V waste. Although the voyages of these ships can be long, less waste is produced by a limited number of crew members. Lack of space for the installation of these systems can also be a cause.

2.3.3 Overview of new technologies to reduce waste

The interviews and surveys showed that there are a number of new technologies which can reduce waste at the source and/or treat the waste in an accordance to the next best step of the waste hierarchy. Some of these technologies and systems are already commercially available, while others are still in development. An overview is shown in Table 6. Information is gathered from interviews, surveys and available information on the internet.

Table 6 - overview of new technologies to reduce a ship's produced waste

Technology/System/ Product	Intended for waste related to MARPOL	Waste hierarchy	Technology readiness
Integrated hydro-pyrolysis	Annex I & V	Recycling	TRL 5-6. Not yet commercially available.
Waste gasification system	Annex I & V	Recycling	TRL 8-9. Commercially available.
Fuel power conditioner	Annex I	Prevention	TRL 8-9. Commercially available.

Integrated hydro-pyrolysis

Description of the system

Integrated hydro-pyrolysis is a thermochemical recycling technology which is able to recycle a mix of plastic and biomass to high quality hydrocarbons or fuels. All combustible waste with a caloric value, such as cargo slobs and garbage (both plastic and biomass) can be used as feed. The technology has two functions:

- conversion of mixed combustible waste (solid and liquid) into MGO and syngas; and/or
- conversion of HFO into MGO.

The produced MGO can be used as fuel for the engines on-board and the syngas for on-board power and heat.

Advantages and opportunities of the system

- Highly efficient. The technology uses the carbon from the waste and/or fuel as energy source leaving only salts as a residual product. The waste reduction rate is therefore
- 97–100%, dependent on the feed.
- Integrated hydro-pyrolysis is a cracking process, which means that no fuel is required for the operation of the system and no emissions are released to the air.
- No char waste, only a small amount of salts from the biomass.

Disadvantages and barriers of the system

- The system requires a space of about a half sea container in the engine room.
- For the current scale, there must be sufficient residual waste on-board to operate the system. The minimum required amount of residual waste for the current developed system is 1,000 tonnes per year. The system is therefore mainly suitable for cruise ships, tankers and other large ships types which produce large amounts of garbage.

Implement ability and applicability

Conventional pyrolysis is already used ashore for the conversion of plastic into fuel, but not yet for conversion of mixed combustible waste. The integrated hydro-pyrolysis system for applicability on-board of ships has currently a technology readiness level of 5 to 6 and the size of a half sea container. Commercial scale testing still needs to be implemented.

Cost efficiency

The investment costs are recovered relative quickly. A land based 10 kiloton/annum integrated hydro-pyrolysis system at the scale of a sea cruise ship costs about 7 million euro's and can be earned back within 6 years. Integration cost for on-board integration of 1 kiloton/annum scale are to be determined (Jaspers, 2020).

Waste gasification

Description of the system

A waste gasification system is a thermal treatment device that decomposes all organic waste into:

- carbon component (bio-char);
- gaseous fraction (synthesis gas).

In an auto gasification system the gaseous fraction ('syngas') is used as fuel for the process, enabling a semi self-fuelling device. Furthermore, it recovers thermal energy.

Advantages and opportunities of the system

- All types of organic waste (such as garbage and sludge) can be processed by the system. Auto Gasification technology avoids the creation of toxic substances associated with conventional thermal treatment devices.
- About 5% of the feed (waste) remains as residual product in the form of bio-char.

Bio-char can be delivered ashore and can be used as soil enricher.

Disadvantages and barriers of the system

- At the moment there is one standardized system available with a throughput rate of 50 kg/hr for dry wastes, sufficient for processing the daily dry waste fraction generated by 100-1,000 persons in 8-12 hours. This means that the system is less efficient for smaller ships and too small in throughput capacity for larger cruise vessels.
- For larger marine assets the overall waste management machinery is highly automated whereas presently available auto gasification system is designed to manual loading, automatic feeding solution are under development.
- One type of waste can be processed at the time. It is not possible to process a mix of sludge and garbage.

Implement ability and applicability

A waste gasification system is commercially available for the shipping industry. At the moment it is mainly applied on offshore construction ships, smaller cruise expedition ships and on R&D ships with more than 100 persons on-board. In some special cases it is applied on dry cargo ships which have less than 100 persons on-board, but which produce a lot of sludge.

Cost efficiency

Capex: the system is about 3 to 4 times more expensive compared to an incinerator (± € 60,000-€ 80,000) (Overloop, 2020).

Waste gasification

Description of the product

Fuel stability and compatibility is an increasing problem for marine heavy sulfur fuels, especially when they are blended with low sulfur fuels. The addition of a fuel power conditioner stabilizes the fuel and prevents the sludge formation in the fuel tanks.

Advantages and opportunities of the system

- stabilization of the fuel;
- prevents sludge formation in the fuel tanks.

Disadvantages and barriers of the system

A fuel power condition must be added manually to the fuel which makes it easy to make mistakes in the addition of the right dosage.

Implement ability and applicability

The product is commercially available. It is unknown what type of ships and how many ships actually use a fuel power conditioner as addition to the fuel, since it was not possible to arrange an interview with the manufacturers or suppliers of this system.

Cost efficiency

The cost efficiency is unknown, since it was not possible to arrange an interview with the manufacturers or suppliers of this product (Wilhelmsen, ongoing).

2.4 Conclusion regarding the applied and new technologies

- There are a few technologies that are required by MARPOL regulations and which therefore cannot be used in criteria to identify that a ship produces reduced quantities of waste. These are oil/water filters with a maximum oil mixture discharge of 15 ppm.
- All other technologies to manage, handle and reduce waste are optional.
- The installation and use of different technologies reflect the quantity and type of waste generated on-board ships, as well as the possibilities ships have to deliver waste in ports or discharge at sea. Cruise ships, which generate much waste and may go on lengthy voyages, tend to have more waste-handling equipment than cargo ships.
- White Box System or other similar systems, incinerators, compactors, crushers, shredders, comminuters, grinders and pulpers are not commonly installed on-board of ships. They have the potential to reduce volumes of waste, but do not reduce the quantity of waste at the source.
- New technologies with the potential to reduce or recycle waste on-board ships are a few, but even when they are not yet commercially available, it can be useful to encourage them.

3 Inventory of operational practices and management systems

The production of waste has consequences for the environment. All involved parties have their own ways for a positive contribution to this issue. The best operational practices of the shipping industry are described in Section 3.1. Section 3.2 explains a number of environmental management systems with waste elements. Port and administration initiatives for fee reduction related to waste reduction can be found in Section 3.3.

A conclusion on operational and management systems is provided in Section 3.4.

3.1 Best operational practices of shipping companies

Shipping companies are more and more aware of the consequences of the production of waste and are involved in the reduction at the source, minimization of volumes produced waste using control measures, as well as managing the waste in an environmentally sound manner. The implemented practices from shipping companies strongly depend on the ship types, the amount of ships in a company, the size of the ships, the operating areas and also on the sustainable ambitions and policies of both shipping companies and ports. The best environmental and operational practices of the shipping companies who participated in this study are listed and described in **Table 7**. All best practices are above the technical requirements of MARPOL. The MARPOL Annex to which they are related is indicated in the table.

The best operational practices can be grouped in three categories:

1. Waste monitoring and environmentally sound management.
2. Reuse and recycling.
3. Waste reduction.

Table 7 - Best operational practices of shipping companies

Practices	Related to MARPOL	Related elements	Description
Monitoring and management			
A dashboard monitoring system	Annex I, V, VI	Equipment & Management	Some shipping companies have a comprehensive dashboard which shows the amount of waste discharged at sea, disposed to the port reception facilities and incinerated on-board per vessel or fleet. The dashboard distinguishes between all type of waste (i.e. plastic, food waste, domestic waste, cooking oil, greenhouse gas emissions, etc.) and the data is shown per quarter. The data required for the dashboards is extracted from the planned maintenance system, where waste disposal is also monitored. By using this dashboard waste production can be analysed and possibilities can be found to reduce waste. Such a detailed monitoring of waste is not common practice amongst the shipping companies contacted in this study.
Monitoring the amount of waste generated on-board	Annex V	Operation & Management	There are shipping companies who have an environmental officer on-board of the ships who measures the weight and volume of waste on-board. All type of waste (paper, plastic, etc.) is measured separately for sustainability reporting purposes. The data is analysed on shore in order to identify options to reduce waste.
Company policies related to the	Annex V	Management	Some shipping companies have additional non-statutory company policies related to the environment and the

Practices	Related to MARPOL	Related elements	Description
environment and waste management plan			waste management plan. Possible company policies are: – No garbage overboard policy – Sustainable procurement policy (contracts with sustainable suppliers, direct return of packaging after delivery of stores, no single-use plastic, bulk packaging, biodegradable packaging & reduction of plastic packaging)
Creating crew awareness	All Annexes	Management	Creating crew awareness (for example on officers conferences) about the fact that they also able to reduce waste by themselves by explaining the importance of reduction, segregation and recycling of waste (such as paper, plastic, water use, etc.). The same applies to sustainable procurement and the ordering of products.
Office department fully focused on waste reduction	All Annexes	Operation & Management	Some shipping companies have an office department fully focussed on possibilities and solutions to reduce and minimize the produced quantities of waste.
Reuse and recycling			
Using waste hierarchy	All Annexes	Operation & Management	The waste hierarchy is a tool to rank waste management options according to what is best for the environment. The waste hierarchy consists of prevention, reuse, recycling, minimization and disposal. Shipping companies are aware of the waste hierarchy and have their own ways to contribute positively to the environment and environmentally sound management.
Waste segregation	Annex V	Operation & Management	Some shipping companies sort their waste very extensively in accordance with the waste collectors. There are shipping companies that have contracts with certain waste collectors which include conditions of waste handling and recycling.
Analysis of the waste processing ashore	Annex V	Operation & Management	Some shipping companies segregate waste by type, but it is not yet possible to deliver all types of waste separately everywhere in the world. In addition, the waste treatment process ashore is on some locations more environmentally friendly than on other locations. For this reason, some shipping companies are investigating the onshore waste treatment processes to select, based on the results, the waste collectors they want to work with.
Waste reduction			
Use of alternative fuels	Annex I	Ship design, Equipment & Operation	Alternative fuels may have a positive effect on the production of sludge and other oily waste, on greenhouse gas emissions and air quality. The impact depends on the type of fuel. The alternative fuels currently used are mainly biofuels and liquefied natural gas. Special engines are necessary to operate on liquefied natural gas. Biofuels can be blended with conventional fuels.
Use of shore power	Annex I	Ship Design, Equipment & Operation	The generators can be switched off by using shore power in ports. This results in lower production of sludge and oily waste. Additionally, it has a positive effect on noise reduction and reduction of local exhaust gas emissions.

Practices	Related to MARPOL	Related elements	Description
Fuel-efficiency measures (e.g. Weather routing and optimal sailing; Hull cleaning and propeller polishing; and Optimum speed and speed reduction)	Annex I	Equipment & Operation	By using a weather routing and/or optimal sailing tool it can be determined per trip which route is the most optimal in terms of weather, time and fuel. This has a positive influence on the amount of oily wastewater and exhaust gas emissions.
Preventive maintenance and life-cycle management	Annex I & IV	Equipment, Operation & Management	Preventive maintenance and life-cycle management ensure that parts and equipment will be replaced on time to avoid oil spill and unnecessary release of emissions.
Minimization of potable water on-board	Annex IV	Equipment	Minimization of potable water consumption on-board by the use of vacuum toilets and water or water pressure reducing system.
Healthy food in correct proportions	Annex V	Operation & Management	Food quality measurement and the providing of correct proportions to avoid unnecessary food spill.
Paperless documentation	Annex V	Operation & Management	Some shipping companies have a company policy both on-board and in the office for paperless documentation, so that the consumption of paper will be minimized and only used when really necessary.

3.2 Environmental management systems with waste elements

An Environmental Management System (EMS) is one of the possible tools for companies and other organizations to improve their environmental performance. They are voluntary and often designed to ensure compliance with industry best practices and reward those participants that are willing to be more stringent and take measures above the regulatory baseline. EMS is a way to identify, measure and manage the effects of a company's activities on the environment. Often an EMS scheme is developed with the commitment to continually improving their environmental performance by implementing measures through a cycle of Plan, Do, Check, Act (PDCA).

Environmental management systems like ISO14001 prescribed the environmental targets the company voluntarily complies with. Each company set their own corporate environmental objectives and the audit programme checks if the objectives have been achieved and if the continually improvement have been achieved through the following elements:

- An environmental policy.
- Planning to implement the environmental policy:
  - identification and evaluation of the environmental aspects;
  - compliance with relevant legal and other regulatory requirements;
  - documented and quantifiable environmental objectives and targets.
- Implementation and operation:
  - the establishment and maintenance of an environmental management program;
  - evidence of the practical implementation of an environmental management system.
- Checking and corrective action:
  - monitoring and measuring of relevant operational and management activities;
  - procedures for periodic internal auditing of the environmental management system.
- management review of the environmental management system.

The EU Eco-Management and Audit scheme (EMAS) has incorporated the system of ISO 14001 and allows many ISO-certified organizations to step up to EMAS through an uncomplicated process, the main features that distinguish EMAS from ISO 14001 are:

- transparency by external communication strategy by annually publishing an environmental report;
- employee participation and commitment to continuous improvement;
- continuous improvement of your environmental performance;
- registration with a national competent body.

But not all schemes will follow the same steps, some have chosen for indicators of performance from a range of sustainable measures and after verification, the shipping company can be certified or awarded in accordance to its performance index. As the focus for environmental concerns of the maritime policy has changed from marine pollution to air pollution, it is obvious that the majority of EMS, awards systems and incentives are mainly concerned with emission reduction of SO_x, NO_x, PM and climate change. A few schemes have next to the air-pollutions also waste and water included in their requirements.

The study of EMSA, shows the existences of a variety of worldwide initiatives to improve the environmental performance of the maritime industry. It identified "47 different systems and initiatives (not all of them being in operation)" (HPTI, 2007). From this list and additional response from the interviews and internet surveys the current study identified those systems that have specific requirements in relation to waste management of the shipping sector. Most of the information was gathered through internet reports and in some cases through an interview.

ISO 14001/2015

About 80% of the shipping companies that participated in this study indicated that they use ISO 14001/2015 to certify their Environmental Management System. The organization needs to determine the environmental aspects within the scope of its own environmental management system. For determining the environmental aspects the organization can consider the generation of volumes of waste and other elements (air emissions, releases to water and land, use of energy, etc.). As part of the environmental management system is to fulfil compliance obligations and one of the obligations of MARPOL Annex V, is that ships above 100 GT should have a garbage management plan (GMP), it can be expected that waste elements are part of the evaluation done by ISO 14001/2015. But as mentioned before, the specific waste elements evaluated by ISO 14001/2015 would be based on the written procedures, which are obligatory for handling the waste. But these procedures are not required in the GMP for waste reduction at the source and for managing it in environmentally sound management.

Green Award

The Green Award (GA) was established in 1994 and has since been a quality mark for safety, environmental standards and corporate social responsibility for the frontrunners in the shipping industry. The GA provides audits and certifies ships and shipping companies in over 30 countries in Europe, Asia, Middle East, Africa, Australasia and the Americas. GA has over 40 ports providing incentives, usually on their port dues, which can lead up to a discount of 20%. Other incentive providers, inter alia, are banks, marine service and equipment providers (Green Award, ongoing). Certified ships are oil tankers (64%), LNG carriers (29%), LPG carriers, chemical tankers and dry bulk carriers. In additional almost 50 shipping companies are certified.

The GA requirements consist of three parts; the basic requirements (with elements related to ISM, MARPOL and SOLAS), ranking requirements (weighted items, minimum % to be attained) and visual inspections (seaworthiness, good housekeeping). GA provides several checklists for the above-mentioned certified ships, but recently also for container carriers

and Ro-Ro Cargo ships. In general, the system for al ships are the same, with some specification related to the ship type.

A selection of GA requirements with regard to waste reduction and managing the waste in a sustainable and sound manner is provided in the following table, including the minimum ranking score to be achieved. The minimum ranked score per elements is the same for each ship type. What differs per ship type is the total amount of minimum score that can be achieved.

Table 8 – Green Award requirements score with effect on waste production

Green Award Requirements with effect on waste production	Minimum ranking score required
Greenhouse gas emissions/alternative fuels	15
Waste Management/Garbage Handling On-board	55
Ships required to carry out Fuel Change Over to low sulfur Marine Diesel Oil or low sulfur Marine Gas Oil (low sulfur Distillates)	55
Sewage management	20
Grey water management	25
Management of bilge water and sludge handling on-board	85
Programme of inspections maintenance	50
Crew training course	20
Purchasing	80

With a minimum ranking score of 1,820 points for an oil tanker (which is the most common ship to be certified), the above requirements that direct or indirect effect the waste production, represents about 20% of the total requirements for a GA certification. The range between the minimum score to be achieved by several ship types lies between a total of 1,735 and 1,910 points.

ISO 21070 Handling Shipboard Garbage

The ISO 21070 is a standard set by the International Organization for Standardization (ISO) with focus to procedures for the shipboard management of garbage as defined in MARPOL, Annex V. The procedures also include the handling, collection, separation, marking, treatment and storage of Annex V wastes. It sets out requirements for the classification of garbage, colour codes, collection and segregation of garbage, on-board storage, on-board processing of wastes, offloading waste, garbage management, documentation and waste minimisation. The term minimisation here is used as "to minimize the amount of garbage produced", which can be interpreted in the context of this study as reduction at the source, as it specific include avoidance the generation of waste through deliberate purchase of products that have less package (and thus waste) and products with a less environmental impact and specifies suggestions for deliberate purchase (ISO, 2017).

The result of the survey did not show that this standard was used among the respondents of shipping companies, neither that a fee for waste delivery was given by ports and administrations.

Clean Shipping Index (CSI)

The Clean Shipping Index is established in 2007 in Gothenburg. The goal at first was to encourage cargo owners to operate more environmentally friendly ships by quantifying the vessels' environmental performance. Since 2018 an incentive is given by the Swedish government for a reduction of the environmental tax of the fairway dues. Since then more ports (five ports in Sweden and two ports in Canada) started offering incentives for the Clean Shipping Index certificate.
The Clean Shipping Index is an independent labelling system of vessels that combines several environmental aspects in its performance index. The CSI performance Index consists of a questionnaire of 25 questions on 5 parameters, CO_2, NO_x, SO_x and PM emissions, chemical use and waste and water control. For each section points are given for exceeding legal compliance, with a maximum of 30 point that can be scored for each section and a total of 150 points. All sections are equal to another, the CO_2 parameters e.g. does not outweigh the waste and water parameters (Clean Shipping Index, 2020).

Through an accredited verification in accordance to ISO/IEC guide or ISO 17065:2012, usually executed by a classification company, a vessel can be audited and obtain a certificate that represents the level of performance (Clean Shipping Index, 2018).

The level of performance indicated in the certificate is represented as followed:

1. One star, 0-37 point.
2. Two stars, 38-74 points.
3. Three stars, 75-99 points.
4. Four stars, 100-124 points.
5. Five stars, 125-150 points.

The CSI has database of 2,400 vessels who provided their data through a self-assessment (non-verified) and of 116 vessels who have been awarded with a certificate. The awarded ships all score above 100 points, level 4, and most of them have scored the maximum points on waste and water parameters. The 60% of the certified vessel with CSI are Ro-Pax, tankers and general cargo ships. The vessels that are not certified but have provided their data through a self-assessment consist for over 50% of container ships (i.e. 1,200 ships).

The database is open to every incentive provider to see what score a vessel has on which element even if the data from ships that are not verified. An incentive provider such as port can differentiate their fees, based on elements that are in line with their policy. Others reward based on verification of points scored e.g. the Swedish discount on the environmental part of the waterway fee starts at 10% for level 3, 70% for level 4 and 90% for level 5.

The requirements for waste and water elements that can be awarded with are:

- Oily sludge; No incineration of sludge and disposal to treatment on shore (5 pts).
- Bilge water; Active treatment installed and discharge of <15 ppm (4 pts).
- Bilge water; Active treatment and discharged water contains <5 ppm (6 pts).
- Bilge water; Active treatment, discharged water contains <5 ppm and an emission-controlled box is in place (8 pts).
- Bilge water; If all bilge is disposed to onshore facility (8 pts).
- Sewage; no discharge of black or grey water in sensitive areas or a sewage treatment plant (5 pts).
- Garbage; No incineration of garbage and a separate collection for reuse, recycling or disposal (6 pts).
- Crew awareness; education of personnel on environmental awareness, health risks and adequate protective equipment (3 pts).

National Pollutant Discharge Elimination System (NPDES)

A small group of the respondents to the survey, sailing in the United States (U.S.) waters, have adopted a more stringent discharge requirements above the baseline of the MARPOL Convention requirements. For the U.S. a vessel may discharge a pollutant without violating prohibition of their Clean Water Act by obtaining authorization to discharge under the NPDES. The permit is for discharges incidental to the normal operation for non-recreational vessels larger than 24 meters. An NPDES permit authorizes the discharge of a specified amount of a pollutant or pollutants into receiving waters under certain conditions. Next to the general permit which is included in the Vessel General Permit (VGP), an individual permit is needed that is specifically tailored for an individual discharger.

The effluent limitations exceed the current MARPOL Convention discharge requirements as its principles are based on the following:

1. Best practicable control technology currently available (BPT).
2. Best conventional pollutant control technology (BCT).
3. Best available technology economically achievable (BAT).

The general effluent limits include requirements for material storage, containment of toxic and hazardous materials, precautions to prevent fuels spills and overflow, general training requirements for crew and compliance with other statutes and regulations such as the MARPOL Convention.

Additionally, to the MARPOL Conventions, the permit requires the following for discharge of bilge water:

- vessel operators are required to minimize bilge water generation by practicing proper maintenance of vessels and equipment.

Furthermore, there are specific requirements for ballast water, antifouling hull coating leachate and other discharge requirements which do not fall under the scope of this study. The VGP inspections and recordkeeping requirements do not apply worldwide, but it can be concluded that a vessel that has a NPDES permit, has more stringent equipment on-board, a strict maintenance regime and operational procedures to minimize the generation of bilge water.

Blue Angel eco-label

The Blue Angel has two environmental standards for ships; one is the Environmental-Conscious Ship Operation (uz110) and the other is the Eco-friendly Ship Design (uz141).The standard uz110 will not be continued after January 2021 and therefore will not be specified further. The uz141 (valid until March 2021) regarding the eco-ship's design is being revised at the moment. The specific requirements mentioned here are based on the criteria set in 2013 (RAL gGmbH, 2013).
The uz141 covers a variety of elements, such as the environmental protection in ship design, the structural protection from accidental environmental pollution, the reduction of operation-related emissions (including waste) and additional criteria for tank construction. A ship included in the application for the Blue Angel eco-label must fulfil all of the mandatory requirements for the relevant type of ship and also achieve a certain number of points by implementing optional requirements. The mandatory and/or optional requirements are based on the existing regulations from the IMO yet go above and beyond the legal requirements. The Blue Angel eco-friendly ship design seems to be applied by 10 German ships (one of them being a cruise, Ro-pax, Petrol and a working ship) and is not incentivised yet by ports (Blue Angel, ongoing).

The minimum points given in the table for each individual category of ship must be achieved as followed.

Table 9 – Overview of score Blue Angel Eco-friendly ship design

Uz141	Possible total number of points	Minimum number of points required
Cargo ships	145	51
Passenger ships (Pax)	150	53
Tankers	163	57

On the part of environmental protection in ship design no requirements are made in relation to waste production, most of the requirements is in the focus of environmental safety. On the part of reduction of operation-related emissions there the following requirements with regard to the waste elements. Some are mandatory (m) or optional (o) and thus rewarded with points. Furthermore, there are requirements for ballast water treatment, use of lubricating and hydraulic oils, application of antifouling, use of cleaning agents and underwater noise.

Requirements for Bilge water Treatment (MARPOL, Annex I)

- maximum legal discharge of oil mixture into the sea of 5 ppm (m);
- creation of the possibility for exclusive onshore disposal through the installation of tank capacities designed to cope with the expected volumes and the anticipated length of travel (6 points);
- conceptional implementation of the "Integrated Bilge Water Treatment Systems" (IBTS) for treating bilge water in engine rooms based on MEPC Circular 76021 (4 points);
- conceptional implementation of bilge water free ships (8 points).

Requirements for Garbage, MARPOL Annex V

- Structural design facilitating the use of reusable and large packaging (3 points).
- Cargo ships (m):
  - no shipboard waste incineration;
  - discharge of all garbage to onshore facilities;
  - adequate structural on-board storage facilities, possibly in combination with facilities for waste volume reduction, such as presses, shredders, etc.
- Passenger ships (m):
  - verification of the installation of storage space and/or facilities for volume reduction;
  - if the ship is equipped with an incinerator: Verification of compliance with the above-mentioned limits (certificate for the system).
- Passenger ships (o):
  - Process instructions for the incineration system that forbid the incineration of printed, color, high-gloss paper and materials containing PVC (2 points).
  - Ship-generated waste must be incinerated in compliance with all of the limits specified in the 17th Federal Emission Control Ordinance (BImSchV). As a matter of principle, the ash must be disposed of on land (4 points).
  - No shipboard waste incineration. Structural designs are to be provided that guarantee the complete disposal of waste on land (6 points).

Requirements for Sewage, MARPOL Annex IV

- No use of chlorine or halogen compounds for the treatment of wastewater that is discharged into the sea (m).
- Collection of all of the wastewater in storage tanks and onshore disposal (6 points).
- Passenger ships (m):
  - use of a membrane system or comparable efficient technology;
  - collection of preliminary clarification products in storage tanks for incineration or disposal on land;
  - the collection of bio sludge in storage tanks for incineration or disposal on land.

- Cargo ships (o):
  - collection of preliminary clarification products in storage tanks and onshore disposal (2 points);
  - collection of bio sludge in storage tanks and onshore disposal (3 points).
- Passenger ships (o):
  - installation of a system that ensures the immediate observance of the limit values proposed by HELCOM20 for the special areas according to MARPOL Annex IV Regulation 9.2.1 (5 points).

Requirements for grey waters, not regulated by MARPOL

- Passenger ships (m):
  - no use of chlorine or halogen compounds for the treatment of wastewater that is discharged into the sea;
  - use of a membrane system or comparable efficient technology;
  - collection of preliminary clarification products in storage tanks for incineration or disposal on land;
  - the collection of bio sludge in storage tanks for incineration or onshore disposal.
- Passenger ships (o):
  - collection of the total grey water and onshore disposal (7 points);
  - installation of a system for the immediate observance of the limit values proposed by HELCOM for the special areas according to MARPOL Annex IV Regulation 9.2.1 (6 points).
- Cargo ships (o):
  - no use of chlorine or halogen compounds for the treatment of wastewater that is discharged into the sea (3 points);
  - collection of the total grey water and onshore disposal (5 points);
  - collection of the preliminary clarification products and onshore disposal (2 points);
  - collection of the bio sludge and onshore disposal (3 points).

Requirements for tank ships

- installation of a vapor recovery system or alternative system (m), MARPOL, Annex VI;
- no release/discharge of slop into the marine environment, meaning adequate storage tank capacity for later discharge on land (m), MARPOL Annex II;
- installation of a super-stripping system (m), MARPOL Annex II.

Green Marine Europe

Green Marine Europe is an environmental certification program for the European maritime industry. It is a voluntary initiative that addresses environmental issues through its 13 performance indicators. To receive a certification, participants must benchmark their annual environmental performance through the program's self-evaluation guides and have their results verified by an accredited external verifier and agree to publication of the individual results (Green Marine, ongoing).

The performance indicators that apply to shipowners and have a direct relation with waste management on-board ships are Oily Discharge and waste management. The green marine has five levels of compliance, each step with more stringent requirements, see **Table 10**.

Table 10 – Overview of 2020 performance indicators for shipowners with the regard to MARPOL, Annex I and V

2020 criteria	Oily discharge ships >400 GT	Waste management
Level 1	Monitoring of regulations	Monitoring of regulations
Level 2	Monitor, periodically test oil content alarm, the use of seals or locks, indication responsible persons, coordination with the navigation bridge, preferably day-time operation, cleaning of bilges, reduce the use of emulsifying cleaners and agents.	2.1. Equip all of the company's ships with recycling bins and give staff proper training on established user procedures and the waste management hierarchy (reduce, reuse, recycle, recovery, disposal). 2.2. Favour suppliers that use less packaging. 2.3. Encourage the use of reusable, biodegradable and/or recyclable supplies. 2.4. No shipboard incineration at port. 2.5. Domestic ship owners only: Reuse as much as possible dunnage, lining and packaging material.
Level 3	3.1. Oily Water Management plan. 3.2 Annual inventory of bilge water (produced, treated, discharged to sea, and off-loaded to shore, as applicable) and of oil residue (sludge) on a vessel by vessel basis and for the fleet as a whole. 3.3 Develop and adhere to environmental procurement guideline for cleaning products to be used within the engine room.	3.1. Produce an annual inventory of different types of garbage generated in the company's entire fleet and indicate the company's actual garbage management practices.
Level 4	4.1. Adopt a modernization policy for oily water separators and all related control and verification equipment. Implementation on at least one vessel in the company's fleet. 4.2 Vessels built after January 1st, 2011: Implement an integrated bilge treatment system such as that defined in the IMO's revised guidelines (MEPC.1/Circ.511, 18 April 2006). OR 4.3: Vessels built before 2011: Demonstrate an integrated bilge treatment system approach.	4.1. Develop and implement a garbage management strategy defining targets, tools and measures for reducing garbage generated, reducing discharge at sea and increasing recycling.
Level 5	5.1. Vessels built after January 1st, 2011: Implement an integrated bilge treatment system such as that defined in the IMO's revised guidelines (MEPC.1/Circ.511, 18 April 2006). OR 5.2. Vessels built before 2011: Demonstrate an integrated bilge treatment system.	A 5.1. Demonstrate continual improvement by achieving targets defined in the garbage management strategy.

Environmental Class Classification

There are ship classification bureaus that offer a special class for ships that demonstrate the ships commitment beyond statutory compliance such as;

- Lloyds Register ECO notation for environmental performance.
- The Det Norske Veritas Clean and Clean design for new ships (DNV-GL, ongoing).
  - Clean notation shows compliance with all mandatory MARPPOL requirements regardless of any exemption granted by a flag state administration. In addition, it contains additional requirements to prevent oil pollution. It also requires a vessel to have improved technical and management procedures to reduce discharges to sea and emissions to air.
  - Clean Design contains all Clean notation requirements plus additional Constructional and Design requirements such as stricter oily tank protection, installation of 5 ppm oily bilge separator and alarm, installation of approved ballast water treatment system. Clean Design also requires Compliance with Hong Kong Convention for Ship Recycling.

3.3 Port and administration initiatives for free reductions

European ports and administrations apply various criteria for fee reduction based on the type of waste of importance to their region e.g. the type of ships calling their port, as well as their particular circumstances, such as their geographical location and policies that correspond with their environmental roadmap. The decision to provide incentives for delivery of waste based on criteria for determining that a ship meets the requirements for producing reduced quantities of waste are therefore taken by the port in function of their commercial strategy and financial viability.

Almost 30% of the port respondents apply some kind of fee reduction based on an environmental element, such as climate change, air borne emissions and safety.

Examples of reduction given on port dues based on the current green labels are:

- the Environmental Ship Index (ESI);
- the Green Award;
- ISO 14001/2015;
- the Clean Shipping Index.

None of these above-mentioned environmental labels are specific related to waste only and thus the reduction is often given on the port dues instead of on the waste delivery fee. Some of the above labels do have waste components as a part of their system, such as the Green Award and the Clean shipping index.

Fee systems

The port dues is a charge, similar to the indirect fees for waste delivery, to all ships entering the port and generally calculated on the gross registered tonnage of the ship as per the tonnage certificate issued for that ship. The main difference between these fees is which costs are covered by them. Each port has its own methodology of charging such port dues intended for recovery of investments and costs associated with port operations, such as port safety, security and common user infrastructure. Additionally, ports charge cargo specific fees, service and utility fees. The waste delivery fees are usually charged separately and specific for the coverage of the costs related to function of the port reception facilities. These costs are specified in annex 4 of the PRF Directive.

According to the Horizontal Assessment Report on the repealed PRF Directive (EMSA, 2010), the current CRS applied by ports and administrations for the delivery of waste, is a variety of models coexisting next to another. The system could be categorized in three major groups (UNEP, 2019):

1. Indirect fee (or the no special fee system), charged for every ship irrespective of their use of facilities.
2. Administrative waste fee/contribution system (ADM): these charge ships a fee, which is partly based on the amount of waste, delivered, and an additional fixed fee, which is refundable on delivery of waste.
3. Direct fee only system: charge port users based on the volumes of waste discharged, without an additional standard fee.

The reduction of fee based on the CRS is usually applied through the indirect fee and/or through the administrative fee. A reduction of the direct fees is not considered feasible for several reasons:

a The direct fees are not charged by ports, but charged by the operator of the port reception facilities, therefore it is out of the influence of ports to set criteria for a fee reduction.
b The direct fee is directly linked to the volume of waste discharged, there is an implicit incentive for the ship owners to reduce the volumes and a result to keep the operational costs as low as possible.
c Furthermore, to provide a reduction of the direct fee based on volume reduction of discharged waste at the PRF, could be counterproductive. On the one hand the focus would be on volume minimization through the use of equipment such as compactors, instead of reduction at the source by taking measures that better fit the environmentally sound management of a ships waste production. On the other hand, it could be that possible obtained reduction in fees based on volume reduction of discharged waste at the PRF could provide an incentive for ships to discharge their waste at sea.

Reduction of the waste delivery fee

The following initiatives for fee reduction based on a waste component were identified during the study:

- **Ships that exclusively use alternative fuels instead of conventional fuels (MARPOL, Annex I)**

  Some ports give a reduction for LNG ships only, other ports describe it as a reduction for ships that do not use MGO/MDO and/or HFO, which keeps the openness to LNG, hydrogen, methanol and other future alternatives. The base for reducing the fee is that these ships demonstrate that they do not produce liquid oily waste such as bilge water and sludge (MARPOL, Annex I). At least two ports in the North Sea reduce the total amount of the indirect fee with 50%. These ports both have an indirect fee system that is used to cover the costs involved for the collection of MARPOL Annexes I and V. Usually the ship has to apply a request with the local administration/port authority, when granted the reduction can be implemented.

- **Cruise ships that deliver their sewage (MARPOL, Annex IV)**

  The base for this incentive is to encourage ships to deliver their sewage to the wastewater system as the wastewater plants on land provide a better and sustainable treatment than on-board. Not only is sewage covered by the indirect fee without volume limitations, but when connected to the system a 20% reduction is given on the indirect fee.
  The geographical situation of this port is relevant for these choices as it is situated at the Baltic sea — which is appointed as a special area for MARPOL, Annex IV —

and in specific cases such as at the port of Helsinki, most of the port calls from cruises are from non-EU countries.

- **Ships that deliver their waste pay no administrative fee**

  A reduction of the administrative fee when waste is delivered to PRF operator. When the fee charged by the port is only used for the cover of administrative costs, such as organization, management, etc., the ship does not pay the administrative fee when they deliver their waste to the PRF collector. Only direct charges related to volumes are charged.

  The PRF Directive requires that no direct fees are charged related to volumes of MARPOL, Annex V (with the exception for excessive quantities). Thus, the part of the administrative fee cannot only be charged for administration, management, etc., but should also include the costs of Annex V wastes. A revaluation of this incentive is needed.

- **Type of trade and short sea shipping trade**

  Ferries and ships engaged in short sea shipping may benefit from reduced fees if they have signed a contract for the deposit of their operating waste in a port located on their schedule.

- **Reduction of fairway fees for vessels in Sweden**

  The fee system for the fairway fees in Sweden consist of two parts a readiness fee calculated on the vessel's net tonnage and a vessel-based fairway fee, calculated on the vessel's environmental impact and net tonnage. Vessels with a CSI class gets a reduction on the vessel-based fairway fee starting with 10% for class 3, 70% for class 4 and 90% for class 5. The CSI requirements includes waste and water elements to their scheme. Depending on the total score of the vessel, especially when the ship has a class 5 certificate, a minimum of 20% of the score consists of waste and water requirements.

3.4 Conclusion on operational and management systems

- There are several best operational practices with regard to waste handling. They can be categorised as:
  - waste monitoring and management systems;
  - recycling and reuse; and
  - waste reduction and prevention equipment and practices.
- There is much variation amongst shipping companies with regard to the practices they implement.
- Several companies adhere to standards, others participate in voluntary initiatives, and yet others implement company-specific policies.
- There are some EMS, award and labels that include waste element requirements to their scheme. Most of these requirements are optional and are part of a total score.
- The most applied EMS is ISO 14001/2015. Depending on the shipping company's policy, waste is included, but it is not a specific requirement.
- The Blue Angel eco-friendly ship design has next to the optional also mandatory requirements for waste.
- European ports apply various criteria for water delivery fee reduction based on the type of waste of importance to their region, as well as their particular circumstances and policies that corresponds with their environmental roadmap. The decision to provide incentive based on criteria are therefore taken by the port in function of their commercial strategy and financial viability.

- The execution of the port fee reduction is done through the indirect fee and/or through the administrative fee. A reduction implemented on the direct fees is not considered feasible.

4 Analysis of elements for the identification of criteria

Chapter 2 and 3 provides an overview of the current and new technologies, equipment and best operational practices on-board of ships related to waste reduction and volume minimization. The interviews and surveys show that different stakeholders such as shipping companies, ports/administrations, waste collectors and inspectors have different views on waste reduction and volume minimization measures on-board of the ships, which lead to considerations that should be taken into account. Section 4.1 focusses on the considerations for the identification of criteria. Section 4.2 provides the ranking of criteria elements by both ports and shipping companies. The main similarities and different views regarding these measures in relation to ship design and equipment are explained in Section 4.3 and 4.4 and in relation to ship operation and management in Section 4.5.

4.1 Considerations for the identification of criteria

There are several considerations that should be taken into account when identifying criteria to determine if a ship produces reduced amount of waste and manages its waste in a sustainable and environmentally sound manner. Some considerations originate directly from the regulatory framework, other from the analysis of the responses gained through the survey and interviews held with the stakeholders. These considerations have effect on the technical, administrative and practical perspective.

From a regulatory perspective the following considerations should be taken into account:

- The criteria should be directly linked to waste reduction on-board ship and to sustainable and environmentally sound waste management, according to the PRF Directive.
- The management of waste from ships must be done in an environmentally sound manner and in accordance with Directive 2008/98/EC:
- The waste hierarchy must be applied as a priority order in waste management as follows (a) prevention, (b) preparing for reuse, (c) recycling, (d) other recovery e.g. energy recovery, and (e) disposal.
- All used technologies and best operational practices should be above baseline requirements set by the MARPOL Convention, see Annex E.
- The CRS, including the reduction of the waste delivery fees, must not provide any incentives for ships to discharge their waste at sea.

From an administrative perspective, it should be taken into consideration that the cost recovery system applied by ports and administrations contains a diversity of fees combined. Ports and administrations are usually the organizations that charge the indirect fee as part of a contribution to the total costs of the operation of the PRF. Direct fees are directly charged by the waste collectors in relation to the types of waste and volumes discharged. This entails that:

- The direct fee is a market-based fee, ports and administrations do not have influence on the amount charged.
- The direct fee is in direct relation to the volumes of discharged waste, there is an implicit incentive for ships to reduce their waste volumes.
- The reduction given based on the identified criteria to reduce waste should be applied on the indirect fee that is paid by all ships and in relation to those wastes covered by the indirect fee.
- The total fee reduction given by a port or administration should take into account that the coverage of the costs related to Annex V is still sufficient.
- A ship should not be compensated twice. If energy efficiency measures do not have a direct relation to the waste process, it's a side effect and should not be rewarded in relation to waste as there are other rewards for efficiency, such as lower operational costs.

Equipment to handle produced waste on-board ships are not always necessarily good for the marine environment for a number of reasons:

- When ships have the choice between legally discharging at sea and discharging in port, the latter generates more waste in ports from ships, but it may be better for the environment. For example, a ship which discharges the bilge oily water at sea in accordance with MARPOL, Annex I through an oily water separator (<15 ppm) will have less oily waste at her port of arrival than a ship which does not discharge at sea.
- Likewise, the use of incinerators or compactors on-board ships reduces the volume of waste deposit in ports, but incinerators cause air pollution and compactors prevent the sorting and recycling of waste according to the waste hierarchy.
- The presence of equipment on-board does not imply their use. If an equipment is identified as part of the criteria for waste reduction, it is necessary to verify that they are used and maintained.

The considerations from a practical point of view are:

- The system for waste delivery fee reduction should not be complex and should entail limited administrative burdens to ports, administrations, and shipping companies.
- The criteria should be clear and preferably not contain a long checklist.
- Ports do not have a verification system yet to check if the criteria are in place on-board ships. Among those European ports who already apply similar criteria, the preference is for a system with a valid recognition and or certified environmental management system.
- There are several differences between ports and administrations, one unified set of criteria could interrupt the specific regional circumstances and preferences.
- Ports are organized differently therefore it could be an obstacle for a ship to obtain a waste fee reduction based on criteria, in the case that several formal procedures are needed in different ports.

Because the ultimate aim of the PRF directive is 'to protect the marine environment against the negative effects from discharges of waste from ships', the criteria should make sure that they do not create perverse incentives to use solutions that ultimately do not contribute to environmental protection.

4.2 Ranking of waste reduction and minimization measures

Both ports and shipping companies have ranked waste reduction and environmentally sound management measures related to ship design, ship equipment, ships operation and management. The top 10 chosen measures are shown in **Table 11**. The complete ranking of all measures is shown in Annex F. Both ports and shipping companies confirmed during the interviews and surveys that the presented list was complete and no important elements or measures were missing. The main similarities and differences in visions are explained in Section 4.3 to 4.5.

Table 11 - Ranking of waste reduction and environmentally sound measures by ports and shipping companies who participated in the study

Ranking of waste reduction and environmentally sound management measures		
	Ranking of the ports	**Ranking of the shipping companies**
1	Use of alternative fuels	On-board waste segregation
2	On-board waste segregation	Sewage treatment systems
3	Avoiding single use plastic	Use of alternative fuels
4	Ensured separated waste delivery in ports	Avoiding single use plastic
5	Electric propulsion	Energy efficient ship design (EEDI)
6	Energy efficient ship design (EEDI)	On-board recycling/reuse

Ranking of waste reduction and environmentally sound management measures		
7	On-board recycling/reuse	All waste delivered in EU ports
8	Certified waste management index	Ensured separate waste delivery in ports
9	Sewage treatment system	Compactors
10	Food waste digesters	Shore power

For the identification of criteria, a selection of **Table 11** is made based on the analysis of the different views and accordance with the principle of reduction at the source and environmental sound management. Even though equipment are rated in the top 10, they are not always identified as criteria. The choices made are explained in the next paragraphs of this chapter.

4.3 Criteria concerning ship design

The main influence of ship design in relation to waste reduction is the influence it has on the production of oily liquid waste (MARPOL, Annex I), such as oily bilge water and sludge. The generation of sludge has a direct relation to fuel consumption and is a residual waste that is applicable to all types of vessels using conventional fuels. The generation of oily bilge water depends on the size of the ship, the design of the engine room and the age of the engines.

The importance of ship design as a criteria for a fee reduction has been ranked by ports and shipping companies as presented in **Table 11** and Annex F The most important information and views gathered during interviews on these measures are described below.

Alternative fuels

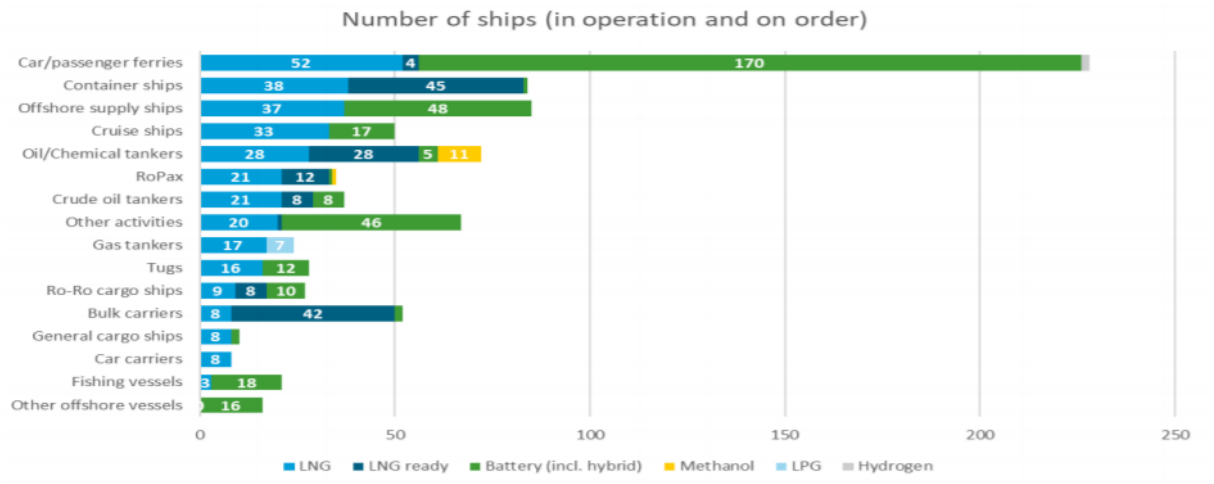
While petroleum derivatives (heavy fuel oil, diesel oil and marine diesel) have been the predominant marine fuels of the past decades, technological developments and environmental regulations are drivers to change to alternative fuels. Liquefied Natural Gas (LNG) and biofuels are mentioned as the main sustainable (transitional) solutions and have therefore received the most attention, mainly because both are compatible with the current infrastructure and/or techniques. A number of other fuels, such as methanol, ammonia and hydrogen, and other technologies such as fuel cells are also options that can be chosen from in the coming decades.
The use of alternative fuels is both from ports and the shipping perspective one of the most important ways to reduce sludge. The choice for alternative fuels such as LNG, methanol, ammonia, hydrogen and other future alternatives and their capacity to eliminate sludge production, are considered as waste prevention options and are in the top of the waste hierarchy.

An EMSA study (CE Delft ; CHEW , 2017) estimated the amount of sludge productions to be in general 1.0 to 1.5% of the daily HFO fuel consumption and 0.5% of the daily MDO fuel. Since the alternative fuels are produced from other sources (such as gas or hydrogen), no sludge will be produced.

However, emissions are still released during the combustion process. A comparison of the CO_2 emissions and NO_x emissions of both conventional and alternative fuels shows that only methanol and hydrogen produced from CH_4 contains more CO_2 emissions compared to the conventional fuels HFO and MGO (DNV-GL, 2019a). Biofuel are creating equal to more NO_x emissions compared to HFO and MGO. All other alternative fuels produce less emissions.

Figure 4 shows the number of ships per ship type which are using alternative fuels in 2019 (DNG-GL, 2019b). The figure shows that most of the ships using alternative fuels are using LNG. Methanol is slowly emerging.

Figure 4 - Number of ships (in operation and on order) using alternative fuels, July 2019



Source: (DNG-GL, 2019b).

In sum, there is a strong relation between the use of alternative fuels and the amount of sludge. An additional advantage is, dependent on the alternative fuel type, the reduction of greenhouse gas and air pollutant emissions. The use of alternative fuels such as LNG, methanol and possible future fuels like ammonia and e-fuels contributes both to reduction of waste at the source and to environmentally sound management and can therefore be used as criteria.

Energy Efficiency Ship Design Index

The Energy Efficiency Design Index (EEDI) sets a standard for energy efficiency of new ships per capacity mile (e.g. grams CO_2/tonne mile). On average, ships with a more efficient design have a better operational efficiency and hence use less fuel.

The Ship Energy Efficiency Management Plan (SEEMP) is an operational measure which provides an approach for shipping companies to manage ship and fleet efficiency performance over time using, for example the Energy Efficiency Operational Indicator (EEOI) as a monitoring tool.

A CE Delft study from 2016 showed that most new ships were already at the level of the 2020-2024 EEDI requirements and that they were 20% more efficient in comparison with a reference ship (CE Delft, 2016a). There is a significant number of ships that exceed the EEDI limit and obviously ships are choosing more techniques than needed to achieve their EEDI requirements.

Even though newly build ships are more energy efficient and use less fuel and therefore produce less quantity of sludge, some ports emphasize that the relative production of sludge does not change.
An EMSA study (CE Delft ; CHEW , 2017) estimated the amount of sludge productions to be in general 1.0 to 1.5% of the daily HFO fuel consumption and 0.5% of the daily MDO fuel. In the case that an efficient ship, due to operational choices, uses more fuel, the amount of oily sludge production will increase as well. It is therefore in their opinion that it doesn't reduce waste directly. Additionally, the incentive for an efficient ship is rewarded through lower operational costs, an incentive for waste reduction could be perceived as a double compensation.

Nevertheless, both Ports and ship owners rank the EEDI measures in the top 10 of possible criteria. The ports ranked the EEDI on position number 6 and the shipping companies on position number 5.

One must be aware of the differences between design efficiency and operational efficiency. Both efficiency measures do not have to be equal to each other. A ship can for example have a high design efficiency in case dual fuel engines are installed which can run on LNG, but if in practice these engines run on conventional fuels the operational efficiency will not be that high.

In sum, ships with a very good EEDI will use less fuel at the EEDI design point and as a result produce less sludge and oily waste. However, there is no correlation between a ships design efficiency and her operational efficiency. Therefore, a superior EEDI may not always indicate a lower generation of waste.
Because of the indirect link between waste generation and the EEDI, the fact that there is no reduction of waste at the source and the possible double compensation, it would not be considered as one of the prime criteria.

Use of onshore power supply

The use of onshore power supply is ranked by the shipping companies in position number 10, but is not ranked in the top 10 by the ports. The use of shore power has a direct link with sludge production: when using shore power at the berth, the auxiliary engines can be shut off. In this way less fuel will be consumed which also means a reduction of the sludge production and fewer emissions. According to the EU MRV, 6% of the total amount of fuel is consumed by ships at berth. Shore power is mainly suitable for ships which frequently visit the same ports and berths, such as cruise ships and ferries.

At present around 70 ports in Europe offer the use of shore power for certain ship types. Six percent of the marine fuel consumption in Europe takes place in ports. The use of shore power reduces a small quantity of waste based on the reduction of fuel. Therefore it can be added as an additional criteria.

Hybrid-Electric Propulsion

An electric propulsion system converts fuel into electricity which can be used for the propulsion and the operation of the vessel. This measure is ranked on position number 5 by the ports, but is not included in the top 10 of the shipping companies. To determine if this measure results in waste reduction mainly depends on the type of fuel which is used, due to the direct relation of sludge production.

Hybrid electric propulsion is particularly relevant to ferries, offshore vessels and tugs. In addition, hybrid electric propulsion systems are in general suitable in case of large fluctuations in power output, where the battery bank can stand for power peaks so that engines are constantly operating smoothly within an optimal range (GloMEEP, ongoing).

The positive influence on waste reduction is based on whether it can be demonstrated that the used fuel to generate electricity actually results in reduction of sludge production. Therefore it is the alternative fuel which provides the reduction of sludge and not the hybrid-electric propulsion system itself. Therefore, it is not suitable to be identified as criteria.

Wind assisted propulsion

When using wind assisted propulsion, part of the required power is covered by the available wind. Potential options for wind assisted propulsion are rotors, wing sails, towing kites and wind turbines. This results in less fuel consumption which has a positive impact on sludge production. In the right conditions a fuel saving up to 18% is possible on specific ship types and sizes (CE Delft, 2016b).

Although these wind assisted propulsion technologies are still in development and not yet used on commercial scale, they have potential in the reduction of sludge production. However, since the reduction is voyage dependent, it is difficult to verify how much reduction is feasible. For this reason wind assisted propulsion is not suitable as criteria for reduction of waste delivery fees.

4.4 Criteria concerning ship equipment

Regarding the selection of equipment in general as a base for reduction of waste delivery fees, several ports express their concerns about the lack of a control system to verify if the equipment is operated and maintained in the correct way. From the port and administration's perspective, the installation of equipment to reduce waste should show a proper use of such equipment and that the equipment is maintained. Furthermore, the selected equipment should be above regulation and mandatory requirements of a ship.

The current inspection regime is based on the Memorandum of Understanding on Port State Control (Paris-MoU). Port State Control (PSC) is not suitable to verify the management and operation of the equipment installed on-board, especially when they are not technical requirements. In addition, the PSC is often implemented by administrations and very seldom by the Port Authorities whereas the fee collection, and control if a reduction is appropriate, is often a task of the Ports and not of the administrations.

The importance of ship equipment as a criteria for a fee reduction have been ranked by ports and shipping companies as shown in **Table 9** and Annex F. Additional information and different views on these important measures are described hereafter.

Incinerator

An incinerator minimizes waste related to MARPOL, Annex I and V by incineration, but produces ashes as a residual product and emissions during the incineration process. The ships that have incinerators installed are often involved in long voyages and do not have enough storage capacity for the amount of waste which is produced during these voyages. The incinerator offers a solution to this problem. The use of an incinerator also reduces costs by minimizing the volume of sludge and garbage discharge at the PRF.
Some shipping companies have a company policy to not use the incinerator or to use the incinerator as less as possible due to the ashes and emissions which are created as a result.

Depending on the type of incinerator, certain type of waste may or may not be incinerated on-board, such as oily sludge (including the oily part of bilge water), plastics, domestic waste including cardboard and operational wastes including oily rags. Incinerators should only be used to incinerate materials that are specified by the incinerator manufacturer.
Even though an incinerator is not a technical requirement, shipboard incinerators should be designed, constructed, operated and maintained in accordance with the 2014 Standard specification for shipboard incinerators (resolution MEPC.244(66). MARPOL Annex VI requires shipboard incinerators installed after 1 January 2000 to be type-approved and meeting specific air pollution criteria.

The 2017 Guidance for implementation of MARPOL Annex V MEPC.295(71) further elaborates that:

- Some of the disadvantages of incinerators may include the possible hazardous nature of the ash or vapour and the excessive labour required for charging, stoking and ash removal. Some of these disadvantages can be remedied by automatic equipment for charging and stoking, however, the additional equipment to perform automatic functions will require more installation space.
- Some incinerators may not be able to meet air pollution regulations imposed in some ports and harbours or by flag and coastal States when such matters are subject to their jurisdiction.

From a supervisory point of view, it is complicated to check whether the incinerator is used properly. They would appreciate the introduction of rules regarding the use of incinerators or the prohibition of the use for incinerators.

Ports and waste collectors share this opinion and do not consider shipboard incinerators to be environmentally friendly for the following reasons:

1. Incineration prevents recovery of materials. According to the waste hierarchy incineration (with energy-recovery) only follows after prevention, reuse and recycling efforts. For garbage of Annex V it is better to keep it in separate storage and discharged to a PRF which than can implement the waste hierarchy accordantly through recycling.
2. In the case incineration is appropriate in accordance with the waste hierarchy, the (EU) land installations are better equipped, regulated and operated as it is a core business of these companies. Incineration on-board therefore can never meet the stringent requirements of operation and regulation in comparison with land installations.

Furthermore, the use of an incinerator could be seen as not environmentally friendly by environmental schemes such as with the Clean Shipping Index (CSI). The scoring in the CSI depends on several environmental indicators, such as CO_2 and water and waste control. For a ship to obtain a higher score, there should be no incinerator on-board or documentation of no incineration of garbage and sludge oil.

From above reasoning and the fact that the use of incinerators is not ranked in the top 10 measures by both ports and shipping companies, it can be concluded that the use of incinerators should not be identified as a criteria for the reduction of waste delivery fees. To the contrary, it can be concluded that incinerators do not contribute to reduction at the source or environmentally sound management on-board.

Compactor

Ships use compactors to compress waste in order to reduce the volume of the waste on-board. Shipping companies with ships that produce a lot of waste (such as for example cruise ships, dry bulk carriers, container ships and Ro-Ro ships) appreciate this type of equipment. Inspection entities, such as Port State Control, have a neutral opinion about the type of equipment. In their point of view there is nothing wrong with compressing of garbage but the reduction of volume will not reduce the produced quantities of waste. Waste collectors and Port Reception Facilities, on the other hand, are not in favour of compactors. They have the opinion that most crew do not know how waste should be segregated and how the compactor works. It is for example time consuming for a waste collector to separate the paper wrapper from a compressed plastic bottle. This segregation issue also applies to the use of shredders.

Compactors are not ranked by ports in the top 10 measures from **Table 11**. Shipping companies have ranked the compactors on position number 9. This is mainly due to shipping companies who participated in this study with cruise ships in their fleet. Since there are many passengers on-board of cruise ships, a lot of garbage is daily produced. Cruise ships use equipment such as compactors and shredders to reduce the volume of this type of waste.

According to the waste hierarchy waste must be segregated in order to recycle waste. A compactor makes the waste recycling process more complicated. Furthermore, compactors reduce the volume of the waste, but do not contribute to the reduction of the quantities of waste produced or to reduction at the source. For these reasons it does not fit to select the compactor as one of the identified criteria for a reduction of the waste delivery fees.

Sewage treatment system

There are three options to store and treat sewage: a holding tank, a sewage comminuting and disinfecting system and a sewage treatment plant. Almost all ships (see Annex E for exact requirements) need to comply with one of these three options where a holding tank is the minimum requirement. A sewage comminuting and disinfecting system and a sewage treatment plant are beyond the legal requirements. The discharge standard and the discharge area depend on the installed option on-board. Annex E provides additional information about the ship requirements, discharge standard and different discharge areas.

It is up to the shipping companies to determine which systems they use on-board of their ships and how they deal with the discharge of sewage at sea. In practice almost all ships are installed with a sewage treatment plant due to the limit storage capacity on-board and costs for disposal of sewage to the port reception facilities. Shipping companies have therefore ranked the use of sewage treatment systems on position number 2.
However, inspection entities, such as Port State Control, have the opinion that sewage treatment systems not always work properly resulting in untreated sewage being discharged.

Rules regarding the discharge of sewage at sea depends on the geographical area, the used systems and the type of ship, as the discharge from cruise ships in some area is more stringent.

Untreated sewage discharged into the sea must be avoided as part of management of waste in an environmentally sound manner. For this reason, the use of sewage treatment systems in compliance with the effluent standards of IMO Res. MEPC.227(64) can be incentivised by including this measure in the list of identified criteria for cargo ships.

Closed and open loop exhaust gas cleaning systems

Both inside and outside emission control areas the limits regarding sulfur oxides has become stricter the last years. From a cost point of view several shipping companies have therefore installed exhaust gas cleaning systems on their ships. By using these systems, the ships can continue to run on high sulfur fuels which are often cheaper in comparison to low sulfur fuels. Closed loop exhaust gas cleaning systems store the wastewater on-board while open loop exhaust gas cleaning systems discharge the wastewater at sea. Waste from exhaust gas cleaning systems is a new type of waste and it is unknown how much waste it actually concerns. Inspection organizations have therefore net yet clearly formulated their opinion about this type of waste.

Conclusion: There is currently a lot of discussion ongoing about exhaust gas cleaning systems. However, they do not appear in the top 10 measures for both ports and shipping companies. Considering the waste hierarchy, waste have to be reduced and prevented at the source. In this case it means that it would be more sustainable to use clean fuels instead of cleaning dirty fuels. For that reason all exhaust gas cleaning systems are not considered as potential criteria for waste delivery fee reduction.

Food waste digesters

Food waste digesters are systems which are capable of handling and minimizing large quantities of food waste. Because of the large quantities of waste required to make these systems profitable, they are mainly used on cruise ships. Ports have ranked this type of system on position number 10. For shipping companies this system falls outside the top 10.

Conclusion: Food waste digesters reduce the volume of food waste, but do not reduce the quantity of waste itself. The system does not contribute to a reduction at the source and also not the environmentally sound management. For these reasons food waste digesters are not suitable as criteria for the reduction of waste delivery fees in ports.

Shredders

Galley waste and shipboard shredders use rotation blades to minimize waste volumes. Although this technology minimizes the waste volumes, it will not reduce the quantity of waste. In addition, both ports and shipping companies have not ranked this type of equipment in their top 10. For this reason shredders are not suitable as potential criteria for reduction of waste delivery fees in ports.

Oil treatment equipment

Annex E provides detailed information about the required oil treatment equipment with a maximum discharge limit of 15 ppm. Section 3.2 provides more information about the Clean Shipping Index (CSI) which provide additional points and incentives in case oily water is disposed at the PRF's or discharged at sea when the oil water mix contains less than 5 ppm oil after treatment by additional systems. The goal of this type of equipment is to discharge as little oil as possible in the sea which increases the environmentally sound management. The use of additional oil treatment systems to discharge less than 5 ppm oil can therefore be used as criteria for reduction of waste delivery fees.

A pipe and pump system with max. 75 l retained residue

Pipe and pump systems are only used on-board of tankers which transport liquid cargoes in closed tanks. Pumping and piping arrangements ensure that tanks retain a certain quantity of residue in the tanks and associated piping. A maximum of 75 liter retained residue is the highest standard and required for every tanker constructed after the 1st of January 2007. Since this equipment is mandatory and only used by tankers it is not considered as eligible for reduction of waste delivery fees.

New systems related to ship equipment

In addition to the familiar current systems and technologies, it is useful to encourage all kinds of new technology which have potential to reduce a ship's produced waste, but which are not all yet available at commercial scale, by including them in the list of criteria. Examples of new systems related to ship equipment are integrated hydro-pyrolysis, waste gasification and fuel power conditioner. These systems and new technologies are described in Section 2.3.3.

Integrated hydro-pyrolysis

An integrated hydro-pyrolysis system convert mixed combustible waste (solid and liquid) into MGO and syngas and/or convert HFO into MGO. The produced MGO can be used as fuel for the engines on-board and the syngas for on-board power and heat. The system does not contribute to reduction of waste at the source, but reuse the waste. In this way, the system contributes to environmentally sound management and can therefore be included in the list of criteria to reduce waste delivery fees.

Waste gasification system

A waste gasification system is a thermal treatment device that decomposes all organic waste into bio-char and synthesis gas. The synthesis gas fraction is reused as fuel for the process itself and the system recovers thermal energy. The system does not contribute to reduction of waste at the source, but reuses the waste and therefore reduces the waste to be delivered in port. In this way, the system contributes to environmentally sound management and can therefore be included in the list of criteria to reduce waste delivery fees.

Fuel power conditioner

The addition of a fuel power conditioner to the fuel stabilizes the fuel and prevents sludge formation in the fuel tanks. Prevention is part of the waste hierarchy and in this way it contributes to environmentally sound management. However, there are many discussions

ongoing about the use of conventional fuels and the transition of the shipping sector to the use of alternative and cleaner fuels. A fuel power conditioner can be seen as a stimulation to keep using conventional fuels. This is not desirable and for that reason this measure is not included in the list of criteria to reduce waste delivery fees.

4.5 Criteria concerning ship operation and management

In addition to a ship's design and ship equipment, the operation and management measures of a ship can also contribute to the reduction of waste produced by ships. Half of the measures listed in the top 10 in **Table 11** are related to ship operation and management measures.

Sustainable purchasing

All interviewed and surveyed stakeholders (shipping companies, ports, inspection associations, yards and waste collectors) agreed that prevention of waste at the source is the best approach in comparison to all other waste reduction and minimization measures and systems. Important aspects to realize the reduction of waste related to MARPOL Annex V at the source are human behaviour and the selection of the suppliers. It is an awareness process. Packaging which arrive on-board during the delivery of products can for example be returned immediately before departure. Furthermore, shipping companies have the option to buy products in bulk packaging and to avoid single use plastic. Despite the fact that it is not yet possible in every part of the world, agreements can be made about these kind of possibilities with the suppliers. Avoiding single use plastic is ranked by the ports on position number 3 and on position number 4 by shipping companies. Sustainable purchasing is reduction of waste at the source and is therefore suitable as criteria for a reduction of the waste delivery fee. It is mentioned by ports that this criteria is difficult to verify. However, this study shows that there are verification schemes which include this as part of their performance indicator.

Segregation of waste and ensured separate delivery

Next to the fact that all stakeholders agree on reduction of waste at the source, they all agree that segregation of waste makes a beneficial contribution to the entire waste processing chain. Shipping companies have ranked on-board waste segregation as measure on position number 1 and ports on position number 2.

On-board waste segregation is only useful when the segregated waste from the ships can also be delivered separated in ports. According to the PRF directive, Article 4, the separated collection must be insured to facilitate reuse and recycling and PRF may collect the separate fractions in accordance to waste categories defined in the MARPOL Convention. It is therefore not surprising that ensured separate delivery of waste is also included in the top 10 measures. Ports ranked this measure on position number 4 and shipping companies ranked this measure on position number 8.

If ships can demonstrate that they segregate the produced waste and if separate delivery can be ensured by ports, these measures can be used as criteria for waste delivery fee reduction as they facilitate reuse and recycling.

Recycling/reuse Key Performance Indicators (KPIs)

Reuse and recycling are on the waste hierarchy ladder after prevention and minimization and can also make a significant contribution to the reduction of produced ship waste related to MARPOL Annex I and V. Both ports and shipping companies have indicated reuse and recycling as an important element in their top 10 rankings. Shipping companies have ranked this measure on position number 6 and ports on position number 7. If ships can demonstrate (i.e. through the use of KPIs) that they reuse/recycle the produced waste on-board or that they ensure the reuse/recycling process ashore, this measure can be seen

as environmentally sound management and can be used as an additional criteria for the reduction of waste delivery fees as it is not a standalone measure.

All waste delivered in EU ports

The options for separate waste disposal and the quality of waste processing ashore is not equal in every port and country. In general, these matters are better regulated in Europe compared to other parts of the world. For this reason, shipping companies have ranked the all waste delivery in EU ports as measure on position number 7. Ports have not ranked this measure in their top 10. This measure can only be included as criteria in the event that an overview exist which shows which ports and countries (outside Europe) are underperforming in terms of waste separation and waste processing. Ships must be able to demonstrate that they have not disposed waste at these locations.

Conclusion: Because of the administrative workload to create an overview of ports and countries which are underperforming in terms of waste separation and waste processing, it is not useful to select this measure as criteria for the reduction of waste delivery fees.

Certified waste management index

The above described measures are not always easy to demonstrate and quantify for shipping companies which makes is consequently difficult for ports to verify. Section 3.2 describes more environmental management systems which include waste elements. These environmental management systems or certified waste management index have already designed certain scores to ships regarding the way they deal with waste. This can be related to both equipment and management. To save time for ports for the necessary verification, these types of indexes can be useful and used as an additional criteria for waste delivery fee reduction.

4.6 Conclusions

A reduction of the quantity of waste produced or delivered to the PRF is in some cases at odds with managing waste in a sustainable and environmentally sound manner. Criteria should balance these two conditions set in Article 8(5)(b) of the PRF directive.

The circumstances of ports vary. Because of local circumstances, delivery or treatment of certain waste streams on-board may be preferable in some ports, but not in others.

There is broad agreement amongst stakeholders that it is important to combine all the elements (ship design, equipment, operation and management) to reduce and minimize the produced waste on-board in an optimal way. Highly sophisticated systems may be installed on-board, but without proper knowledge of the crew, the systems lose their value.

Conversely, the same applies. There may be a good company policy aimed to reduce waste, but without the right systems on-board, the policy will have less effect. It is therefore important to find the right balance between ship design, the installed equipment, operation and management.

5 Identification of criteria

Every ship is unique in her design, installed equipment, operation and management. Due to the large differences between ship types, it is not possible to identify a unique paradigm to reduce a ship's produced waste. The same applies to ports, which all have different types of ships calling at their port and particular circumstances, such as their geographical location, environmental conditions and their own policies in line with their environmental roadmap.

Therefore, the identified environmentally sound management criteria will not be all equally suitable for every ship type, nor equally useful for each port. Section 5.1 sets general principles for the identification of criteria. Section 5.2 provides a list of identified criteria which ports can chose from to reduce the delivery waste fees for a ship's produced waste. This list is based on the information obtained during this study. The recommendations are found in Section 5.3.

5.1 General principles for identification of criteria

For the identification of general criteria for determining that a ship meets the requirements for design, equipment and operation in order to demonstrate that the ship produces reduced quantities of waste, and manages its waste in a sustainable and environmentally sound manner, the criteria were chosen based on the following principles:

a Prevention of waste at the source.
b Sustainable and environmentally sound waste management.
c Undertaking voluntary additional measures: Higher level of ambition than just complying with mandatory requirements and regulations.
d New technologies that comply with the principles of the waste hierarchy.
e Verifiability of the identified criteria.

With the above principles in mind, the criteria were chosen through the obtained results of:

1. The operational practices of the shipping industry and voluntary environmental management systems and awards.
2. The current practices and available technologies for reduction of waste delivery fees.
3. The top 10 elements for criteria ranked by the shipping companies, port and administrations.

Above lists of principles and obtained results are further explained as followed:

General Principles

a *Prevention of waste at the source.* The waste hierarchy, as defined in the European waste policy contained in Directive 2008/98/EC, which lays down a priority order of what constitutes the best overall environmental options in waste legislation and policy.[3] The first priority of the waste hierarchy is prevention of waste generation. Preparation for re-using and recycling are next in the priority order, following with recovery (like for example combustion for energy recovery) and disposal, which is positioned at the bottom of the hierarchy.

b *Sustainable and environmentally sound waste management* means that waste management is carried out without endangering human health, without harming

[3] While departing from such hierarchy may be necessary for specific waste streams when justified for reasons of, inter alia, technical feasibility, economic viability and environmental protection.

the environment and, in particular, without risk to water, air, soil, plants or animals. Therefore, all measures which improve or minimize the legal discharge at sea and improve a better management to prevent the production of waste are considered as criteria.

c *Undertaking voluntary additional measures:* There are several practices of operation and management systems used by shipping companies linked with waste generation that are above the baseline resulting from compliance with mandatory requirements and regulations. As an example, MARPOL regulations do not prescribe specific technologies. They prohibit the discharge of several types of waste, depending on the location of a ship, and require that bilge water do not contain more than 15 ppm oil when discharged. The use of all other equipment to manage, handle and reduce waste is optional and therefore more ambitious than just complying with regulatory and mandatory requirements.

d *Appliance of new technologies that comply with the principles of the waste hierarchy:* This study demonstrated that a number of new technologies have recently become commercially available while others still remain in the prototype phase. The waste hierarchy and/or environmentally sound management is the basis for the selection of new technologies suitable as criteria for the reduction of waste delivery fees. An important point to consider here is also if the crew has been trained to adequately make use of such innovative systems.

e *Verifiability of the identified criteria:* The importance of this criteria can be demonstrated with the following example: the presence of equipment or management and operational systems on-board does not automatically imply their use. If an equipment is identified as part of the criteria for waste reduction, it is necessary to verify that they are used and applied properly. Among European ports who already apply similar criteria, the preference is for a system with an existing certified environmental management system or equivalent. All identified criteria can be verifiable through systems and documentation visible on-board or in the office, but it is time consuming for ports to verify. To keep the additional required workload as low and simple as possible, it is useful to link the criteria to Environmental Management Systems who already verify these criteria. The CSI and the Green Award can for example be used for the verification of the use of alternative fuels.

Obtained results

1. *Operational practices of the shipping industry and voluntary environmental management systems and awards*.
   There are several good practices of operation and management systems used by shipping companies with regard to waste handling. There is much variation amongst shipping companies with regard to the operational practices they implement. Several companies adhere to standards, such as international standards, labels, indicators or awards. Others participate in voluntary initiatives, and yet others implement company-specific policies. The identified standards in this study that have elements for waste as part of their criteria were used to cross check the identification of criteria, as well as a base for the verifiability of a criteria. The elements were selected based on their potential to reduce waste at the source and for environmentally sound management. Most of the practices are not stand alone measures and therefore are selected as an additional criteria.

2. *The current practices for reduction of waste delivery fees:* European ports and administrations apply various criteria for fee reduction based on the types of waste of importance to their region, as well as their particular circumstances and policies that correspond with their environmental profile. Efforts taken to reduce the waste delivery fee based of waste elements were taken into account.

3. *The top 10 elements for criteria ranked by the shipping companies, port and administrations: Ports, shipping companies and administrations have ranked waste reduction and minimization measures related to* ship design, ship equipment, ship operation and management during the interviews and survey. For the identification of criteria, a selection was based on the analysis of the different views and in accordance with the principle of reduction at the source and/or environmentally sound management. This resulted in the conclusion that EEDI is not included in the list of criteria since there is no direct link with waste generation and thus no reduction of waste at the source.
   Furthermore equipment such as incinerators, compactors, crushers, shredders, comminuters, grinders and pulpers have the potential to reduce the volume of waste (delivered at the PRF or legally discharged at sea), these types of equipment do not reduce waste at the source and or prevent waste production. Neither are they considered as a part of a sustainable and environmentally sound management.

5.2 List of criteria

The general principles for the identification of criteria, as explained in Section 5.1 has led to Table 12 which provides a list of identified criteria which could be eligible to support the decision to reduce the delivery fees for a ship generated waste.

All identified criteria are in accordance with at least one of the first 3 general principles described above in Section 5.1: Prevention at the source, related to sustainable and environmentally sound waste management practices and/or undertaking voluntary additional measures. In addition, the criteria should be verifiable.

The following has been considered for identifying the set of criteria:

- the overview of the current waste handling equipment on-board of ships of companies that participated in the survey and interviews;
- the overview of new technologies to reduce a ship's produces waste;
- best operational practices put in place by shipping companies;
- voluntary environmental shipping management systems and awards.

Subsequently an analysis was done for the top 10 criteria ranked by ports, administrations and shipping companies, where the views of different stakeholders are considered.

The list distinguishes between voluntary used equipment and new equipment. Information is provided regarding:

- the basis on which the criteria are selected (reduction and/or environmentally sound management);
- the related elements (ship design, equipment, operation & management);
- the MARPOL Annexes the criteria is related to; and
- the possibilities to verify criteria.

Table 12 – List of identified criteria for ports to reduce the delivery fees for a ship's produced waste

Criteria	Basis	Related elements	Related to MARPOL	Verifiable
Existing equipment, systems and measures				
1. Use of alternative fuels and other energy sources	Reduction & Environmentally sound management (see Section 4.3)	Ship design, technology & Operation	Annex I	Through verification by Green Award, bunker delivery notes, oil record book.
2. Oily water separator (OWS) <5 ppm	Environmentally sound management (reduction of oil	Technology & Operation	Annex I	Through verification by Green Award, CSI, NPDES, Blue Angel eco-label, Green Marine or

Criteria	Basis	Related elements	Related to MARPOL	Verifiable
	discharged at sea, see Section 4.4)			Environmental Class Classification
3. OWS + alarm system and automatic stop for ships <10,000 GT	Environmentally sound management (reduction of oil discharged at sea, see Section 4.4)	Technology & Operation	Annex I	Through verification by Green Award, CSI, Green Marine, Blue Angel or Environmental Class Classification.
4. Sewage treatment system in compliance with IMO Res.MEPC.227(64) for cargo ships	Environmentally sound management (see Section 4.4)	Technology, Operation & Management	Annex IV	Through the sewage pollution prevention certificate verification by vessel classification and Green Award.
5. On-board segregation and ensured delivery in ports	Environmentally sound management (see Section 4.5)	Operation & Management	Annex V	Through verification by Green Award, ISO 21070, Blue Angel or Green Marine.
6. Sustainable purchasing policies (reduction of packaging materials such as bulk packaging & avoiding single use plastic)	Reduction (see Section 4.5)	Management	Annex V	Through verification by Green Award, Blue Angel, ISO 21070 or Green Marine.
7. On-board reuse and recycling	Reduction & Environmentally sound management (see Section 4.5)	Operation & Management	Annex V	Through verification by ISO 21070 or Green Marine.
New equipment				
8. Integrated hydro-pyrolysis	Environmentally sound management (see Section 2.3.3)	Technology, Operation & Management	Annex I & V	New technology and therefore still need to be added to environmental management systems.
9. Waste gasification system	Environmentally sound management (see Section 2.3.3)	Technology, Operation & Management	Annex I & V	New technology and therefore still need to be added to environmental management systems.

Table 13 provides additional criteria that are less relevant when used as stand-alone criteria, as they have a minor or an indirect contribution to the amount of waste, but which gain importance when combined with criteria mentioned in Table 12.

Table 13 - Additional identified criteria for ports to reduce the delivery fees for a ship's produced waste

Criteria	Basis	Related elements	Related to MARPOL	Verifiable
Use of onshore power supply	Reduction (see Section 4.3)	Ship design, Technology & Operation	Annex I	Verification through the use at ports.
Monitoring system for waste production	Environmentally sound management (creating insight, see Section 3.1)	Technology & Management	Annex I, V, VI	Through verification by ISO 21070 or Green Marine.

Criteria	Basis	Related elements	Related to MARPOL	Verifiable
Recycling Key Performance Indicators (KPIs)	Environmental sound management (see Section 4.5)	Operation & Management	Annex V	Through verification by Green Marine
Creating crew awareness	Environmentally sound management (see Section 3.1)	Management	All Annexes	Through verification by Green Award, CSI or Green Marine.
Extensive data record keeping	Environmentally sound management (creating insight, see Section 3.1)	Operation & Management	All Annexes	Through verification by ISO 21070 or Green Marine.
Certified waste management index	Environmentally sound management (see Section 3.2)	Management	All Annexes	Through verification by all certified environmental management systems.

5.3 Recommendations

The identified criteria listed in Section 5.2 are an overview of measures which can be used to reduce the waste delivery fee based on Article 8(5)(b) of the PRF directive.

Not all identified criteria can stand alone or are applicable in every port due to their particular circumstances and policies or have the same relevance for all ship types. It is therefore recommended that ports and administrations select criteria that fit their specific situation. It is recommended to use the criteria listed in Table 13 in combination with the criteria in Table 12 to reduce the waste delivery fee, as these criteria cannot stand alone or have a small impact on waste reduction.

It is not recommended to rank the identified criteria as some measures are more relevant for certain ports and ship types than others. An example is the use of sewage treatment systems. Some ports in special areas, as defined in MARPOL Annex IV, incentivise the delivery of all sewage to the PRF. In these cases, sewage treatment systems installed on cargo ships are not suitable for a reduction of waste delivery fees in ports.

It is worth to mention that there is broad agreement amongst stakeholders that it is important to combine all the elements (ship's design, equipment, operation and management) to reduce and minimize the produced waste on board in an optimal way. Highly sophisticated systems may be installed on board, but without proper knowledge of the crew, the systems lose their value. Conversely, the same applies. There may be a good company policy aimed to reduce waste, but without the right systems on board, the policy will have less effect. It is therefore important for ports to find the right balance between ship's design, the installed equipment, the operation and management and choose a mix of elements that reinforce each other.

The identified criteria focus on the reduction at the source and at environmentally sound management on board of ships by equipment, procedures and systems, but not on the final delivered quantity of waste to the PRF. It is not about the final quantity of delivered waste at the PRF since sustainable & environmentally sound management could increase quantities of waste delivered in some cases. Such is the case when, for example, equipment is used to reduce the quantity of waste legally discharged to the sea (i.e. a OWS <5 ppm). Even though reduction of waste is the main requirement in the Directive and has to be part of the package.

During the interviews it was also emphasized by the ports and shipping companies that the criteria should be simple to implement and that excessive record keeping related to the implementation of Article 8(5)(b) must be avoided.

Some identified criteria regarding equipment and design should be placed in a broader context, such as the use of alternative fuels. The reduction of waste related to the production of sludge should be seen as a co-benefit of the main objective of reducing greenhouse gas and air emissions. For other criteria, it could mean that the verifiability is difficult since the reduction of waste is dependent on the individual trip.

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A An overview of the main amendments on the article 8 of new Directive (EU) 2019/883

Table 14 - An overview of the main amendments on the article 8

Topic	(EU) 2019/883	Description
Scope of the waste included in the cost recovery system	Article 8.1/8.2(d)	Waste from ships included means all waste, excluding cargo residues and passively fished waste[4], which is generated during the service which falls under the scope of Annexes I, II, IV, V and VI to MARPOL Convention. *Recital (34) "Cargo residues should not be included in the cost recovery system and the application of the indirect fee. The charges for delivery of cargo residues should be paid by the user of the port reception facility, as specified in the contractual arrangements between the parties involved or in other local arrangements.* *Cargo residues also includes the remnants oily of noxious liquid cargo after cleaning operations (MARPOL, Annex I and II)."*
Which ships are included in the indirect fee	Article 2(1), 8.2(a), 9.1	All ships included in the scope of the directive (including fishing and recreational), shall pay an indirect fee, irrespective of delivery of waste to Port reception facility with the exemption of of ships that are engaged in schedule traffic with frequent and regular port calls. if there is evidence of a signed contract with a port waste contractor and waste delivery receipts, has been notified to all ports on ship's route, has been accepted by the port where the delivery and payment takes place The exception does not pose a negative impact on maritime safety and marine environment.
Indirect fee	Article 8.2 (b)	The indirect fee shall cover the indirect administrative costs and a significant part of the direct costs (with a minimum of 30% of the actual delivery in the previous year), as determined in Annex 4.
Direct and indirect costs	Annex 4	The costs are specified in terms of direct operational costs that arise from the actual delivery of waste from ships and indirect administrative costs that arise from the management of the system such as e.g. the provision of infrastructure, concessions for site leasing, actual operation of the collection, the downstream preparation and/or disposal, administration, development of the waste reception and handling plan, organization of the consultation procedures, management of the notification.
Inclusion of MARPOL Annex V in the indirect fee	Article 8.2 (c)	No direct fee shall be charged for waste as defined in Annex V to the MARPOL Convention, other than cargo residues, in order to ensure a right of delivery without any additional charges based on volume[5] of waste delivered.

[4] Member states shall cover, where appropriate, the costs related to passively fished waste from the revenues generated by alternative financing systems.

[5] Except when this volume of waste delivered exceeds the maximum dedicated storage capacity as mentioned in the form set out in Annex 2 to this Directive.

Topic	(EU) 2019/883	Description
Exclusion for passively fished waste	Article 8.2 (d)	In order to avoid that the costs of collection and treatment of passively fished waste are borne exclusively by port users, Member States may decide to cover these costs from the revenues generated by alternative financing systems, including waste management schemes and European, national or regional funding available.
Exclusion MARPOL, Annex VI waste	Article 8.2 (f)	The indirect fee shall not include the waste from exhaust gas cleaning systems, the costs of which shall be covered on the basis of the types and quantities of waste delivered.
Differentiation of fees	Article 8.4	The fees may be differentiated on the following basis: – the category, type and size of the ship; – the provision of services to ships outside normal operating hours in the port; or – the hazardous nature of the waste.
Reduction of fees	Article 8.5	The fees shall be reduced on the following basis: – the type of trade the ship is engaged in, in particular when a ship is engaged in short sea shipping trade; or – the ship's design, equipment and operation which demonstrate that the ship produces reduced quantities of waste, and manages its waste in a sustainable and environmentally sound manner.

B Literature review

The literature review provided a base for the following tasks:

- overview of the present technologies used (Task 1.2);
- development of the questionnaire for the targeted stakeholder's consultation (all tasks);
- development of the questionnaire for the internet surveys for shipowners and ports (Task 1.2 and 1.3).

Reviewed literature related to available technologies and initiatives to reduce amount of waste:

- EMSA study on Ships producing reduced quantities of ships generated waste – present situation and future opportunities to encourage the development of cleaner ships (HPTI, 2007).
- Assessment on how far the current Basel Convention technical guidelines cover wastes covered by the MARPOL Convention (OVAM, 2014).
- EMSA Study on the Delivery of Ship-generated Waste and Cargo Residues to Port Reception Facilities in EU Ports (Ramboll, 2012).
- Reducing ship generated marine litter – recommendations to improve the EU port reception facilities directive (IEEP, 2013).
- Waste Reduction at Sea: Pollution Prevention Strategies on Miami-Based Cruise lines (Mohammed, et al., 1998).
- Analysis and collection of waste management best practices at ports Deliverable D-4.1.1. (MedCruise, 2012).
- The management of ship-generated-waste on-board ships (CE Delft ; CHEW , 2017).
- ISO 21070:2017 Management and handling of Shipboard garbage (ISO, 2017).
- ESPO Environmental report 2019 (ESPO, 2019).
- Environmental management systems (YEE, 2010).
- Successful Practices of EMS, a North American perspective (CEC, 2005).
- UGA Info sheet: From ISO 14001 to EMAS: mind the gap (UGA, 2014).

Reviewed literature related to IMO legislation and standards for on-board processing and management of waste from ships:

- Directive (EU) 2019/883 on Port Reception Facilities for the delivery of waste from ships.
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78).
- Consolidated Guidance for Port Reception Facility Providers and Users, MEPC.1/Circ.834.
- Guidance for the implementation of Marpol Annex V, MEPC,295 (71).
- Standard Specification for Shipboard Incinerators, MEPC. 76 (40).
- Guidelines for the implementation of effluent standards and performance test for sewage treatment plant, MEPC 227 (64).

C Interview participants and used questionnaires

C.1 Interview participants and written statements

Interview participants			
No.	**Company**	**Type**	**Interviewee**
1	Spliethof	Shipping Company	Marco van Rijsinge
2	Carnival	Shipping Company	Emilio Tombolesi
3	Stolt Nielsen	Shipping Company	Fernando Martino (†) & Pierre Domine
4	Maersk	Shipping Company	Christoph Grucza
5	Port of Rotterdam	Port	Ron van Gelder
6	Port of Antwerp	Port	Ide Neele & Katrien van Itterbeeck
7	Port of Helsinki	Port	Andreas Slotten & Jukka Haarni
8	Authority for Environment & Energy - Hamburg	Port	Kay-Uwe Matthiesen
9	Port of Lisbon	Port	Vera Godinho
10	Human Environment and Transport Inspectorate – Ministry of Infrastructure and Water Management	Expert	Marco Buitenhuis & Astrid Driesprong
11	Bek & Verburg	Expert	Kenny Baas
12	Meyerwerft	Expert	Stefan von Hebel
13	United States Coast Guard	Expert	Lorraine Weller
14	Fincantieri	Expert	Bionda Davide & Claudio Deluca
15	Obbotec	Marine equipment providers	Diederik Jaspers
16	Marship Engineering	Marine equipment providers	Jan van Overloop
17	Clean Shipping Index	Certification Societies	Maarten Verdaasdonk
18	Blue Angel (RAL)	Certification Societies	Henrikke Buttner[6]
		Written statements	
No.	**Company**	**Type**	**Interviewee**
1	Visned	Shipping Company (association)	S. Verroen
2	European Association of Fish Producers Organizations	Shipping Company (association)	Guilaume Carruel
3	Euroshore	Expert	Sophie Delair

C.2 Questionnaire for ship owners

C.2.1 Introduction

Thank you for agreeing on being interviewed. This interview is part of a study commissioned by DG Move for the identification of criteria for determining that a ship meets the requirements for design, equipment and operation in order to demonstrate that the ship produces reduced quantity of waste and manages its waste in a sustainable and environmentally sound manner, with a view to being able to qualify for reduced fees for delivery of waste in accordance with Article 8(5)(b) of Directive 2019/883/EU on port reception facilities and the delivery of waste from ships.

[6] We've received general information, but a full interview was not conducted.

The main tasks of this study are:

1. To identify the ship design specifics that are directly related to reduced production of waste and attribute to on-board waste management.
2. To produce an inventory of available technologies in the market as well prototypes that directly or indirectly reduce waste and/or improve on-board waste management.
3. To identify relevant operational practices and environmental management systems which results in reduced waste production and improve waste management on-board.

Ship Generated Waste (SGW) consists in the scope of our study MARPOL Annexes I, II, IV, V and VI waste with the exception of cargo residues.

C.2.2 Use of the information and confidentiality

- We will make notes of this interview that we will ask you to comment on in order to ensure our notes are accurate.
- The notes of the interviews will be used to develop proposals for criteria.
- The level of confidentiality will be your choice. The options are:
  - the notes are attached to the consultation report together with your name and your company's name;
  - the notes are attached to the consultation report together with a general indication of the type of stakeholder your company belongs to (e.g. shipyard, marine equipment supplier, port authority, waste handler, et cetera), and your company:
    - is listed as one of the interviewees;
    - is not listed as one of the interviewees.

C.2.3 Questions on general specifics of the ships

- What is your function/role in the company?
- What type of ship(s) does your company operate?
- How many ships does your company operate and what is the GT range?
- What is the average amount of persons/crewmembers on-board of the ships your company operate? Please, specify per GT range in case there is any difference between the ships.
- Which type(s) of waste do you generate on-board? (Waste related to Marpol Annex I, II, IV, V and/or VI?)

C.2.4 Questions regarding practices/management on-board ships related to waste reduction

- Which factors do you apply that decrease the amount of waste on your ship(s)? (For example sustainable procurement, reduced speed, alternative fuels, et cetera).
- Do you monitor the quantities produced on-board of each type of waste? If yes, please explain how.
- In case you monitor the quantities of waste: is there a reduction or increase of produced waste over the years? And what can be the reason for this?
- Which environmental management system are you using? Such as ISO 14001 (2015), ISO 21070 or EMAS.
- Which waste elements are included in the used environmental management system?
- Are you following any (other) waste procedures? If yes, please explain.
- Is there any type of waste you normally deliver ashore instead of discharging it in the sea when allowed? If yes, what and when? And why is this decision taken?

- Which aspects of the waste hierarchy are applied on-board of your ship(s)? Waste hierarchy: waste prevention/reduction – Reuse – Recycle – Volume minimization – None/Other.
- Does your company have a sustainable procurement policy? If so, does it extend to waste management? And if so, please provide examples.
- What are the operational practices used on-board that result in waste reduction? (For example, optimum speed and speed reduction, fuel quality management and new kind of hull paint and underwater cleaning.)
- What are other best practices known which can potentially reduce waste and which you are not (yet) applying on-board?

C.2.5 Questions on available technologies on-board ships

- Which of below technologies do you have on-board and which technologies do you actually use?

	Installed on-board?	Actually using?
Oily water separator	Yes/No	Yes/No
Incinerator	Yes/No	Yes/No
Sewage treatment system	Yes/No	Yes/No
Compactors	Yes/No	Yes/No
Crushers	Yes/No	Yes/No
Shredders	Yes/No	Yes/No
Comminuters	Yes/No	Yes/No
Grinders/Food pulpers	Yes/No	Yes/No
Pulpers	Yes/No	Yes/No
Pump and pipe system (for tankers) with max. 75 litre of residues	Yes/No	Yes/No
White Box System (WBS)	Yes/No	Yes/No
CD-WOR System	Yes/No	Yes/No
PyroGenisis plasma arc waste destruction system	Yes/No	Yes/No
Chemical/physical treatment	Yes/No	Yes/No
Advanced ozone reactors	Yes/No	Yes/No
Open loop exhaust gas cleaning system	Yes/No	Yes/No
Closed loop/hybrid exhaust gas cleaning system	Yes/No	Yes/No

- Which waste technologies are installed on-board which are not mentioned in above table? And are you actually using these technologies?
- Which technologies are most attractive from a cost-benefit perspective and why?

C.2.6 Questions regarding the possible criteria for the implementation of reduced fees

- Which criteria would you consider to be required for the ship to be able to demonstrate that it produces reduced quantities of waste and manages its waste in a sustainable and environmentally sound manner?
  - regarding the ship's design;
  - regarding the ship's equipment and usage;
  - regarding the ship's operation;
  - regarding the sustainable and environmentally sound management.
- Are there any of above items (ship's design, equipment, operation and environmental management) which outweighs the other items?

C.2.7 Questions regarding the identification of possible criteria for reduction of waste fees

Which of the possible following measures would you consider to be practically quantifiable and measurable, in order to be applicable as criteria "for reduced waste" (multiple answers)? Please, choose between 1 (poor) and 10 (excellent).

Regarding Marpol, Annex I

- Use of alternative fuels (e.g. LNG) yes ☐ no ☐
- Hybrid-electric propulsion yes ☐ no ☐
- Energy efficient ship design (e.g. very good attained EEDI) to produce less oily waste yes ☐ no ☐
- Use of onshore power supply yes ☐ no ☐
- Use of oil treatment equipment yes ☐ no ☐
- Use of kites/wind propulsion to produce less oil waste yes ☐ no ☐
- Use of incinerator/gasification device to treat garbage and/or oily waste yes ☐ no ☐
- Other, please specify

Regarding Marpol, Annex II

- A pipe and pump system with max. 75 l retained residue yes ☐ no ☐
- Other, please specify

Regarding Marpol, Annex IV

- Use of sewage treatment systems also where not required yes ☐ no ☐
- Other, please specify

Regarding Marpol, Annex V

- Food waste digesters yes ☐ no ☐
- Use of garbage treatment/minimization equipment:
- Compactors yes ☐ no ☐
- Shredders yes ☐ no ☐
- On-board waste segregation yes ☐ no ☐
- On-board recycling/reuse yes ☐ no ☐
- Avoiding single-use plastics yes ☐ no ☐
- The use of bulk packaging yes ☐ no ☐
- Ensured segregated delivery in port yes ☐ no ☐
- Use of incinerator/gasification device to treat garbage yes ☐ no ☐
- Other, please specify

Regarding Marpol, Annex VI

- Closed loop or hybrid scrubbers yes ☐ no ☐
- Other, please specify

Regarding operational and management systems

- Certified waste management index yes ☐ no ☐
- All ship's waste is delivered in ports with a high quality downstream treatment yes ☐ no ☐
- Recycling KPIs yes ☐ no ☐
- Extensive data/record keeping regarding waste production yes ☐ no ☐
- Other, please specify

Are there any other comments you would like to mention before the interview is completed?

Thank you for your participation.

C.3 Questionnaire for ports

C.3.1 Introduction

Thank you for agreeing on being interviewed. This interview is part of a study commissioned by DG Move for the identification of criteria for determining that a ship meets the requirements for design, equipment and operation in order to demonstrate that the ship produces reduced quantity of waste and manages its waste in a sustainable and environmentally sound manner, with a view to being able to qualify for reduced fees for delivery of waste in accordance with Article 8(5)(b) of Directive 2019/883/EU on port reception facilities and the delivery of waste from ships.

The main tasks of this study are:

1. To identify the ship design specifics that are directly related to reduced production of waste and attribute to on-board waste management.
2. To produce an inventory of available technologies in the market as well prototypes that directly or indirectly reduce waste and/or improve on-board waste management.
3. To identify relevant operational practices and environmental management systems which results in reduced waste production and improve waste management on-board.

Ship Generated Waste (SGW) consists in the scope of our study MARPOL Annexes I, II, VI,V and VI waste with the exception of cargo residues.

C.3.2 Use of the information and confidentiality

- We will make notes of this interview that we will ask you to comment on in order to ensure our notes are accurate.
- The notes of the interviews will be used to develop proposals for criteria.
- The level of confidentiality will be your choice. The options are:
  - the notes are attached to the consultation report together with your name and your company's name;
  - the notes are attached to the consultation report together with a general indication of the type of stakeholder your company belongs to (e.g. shipyard, marine equipment supplier, port authority, waste handler, et cetera), and your company:
    - is listed as one of the interviewees;
    - is not listed as one of the interviewees.

C.3.3 Questions regarding the application of reduced fees in ports

- What cost recovery system for waste collection is in place in your port?
- In case an indirect fee is applied:
  - Which waste streams are included in the fee?
  - Are the ships allowed to dispose an unlimited amount of waste? If not, what is the criteria?
- On what basis is the indirect fee calculated?
- Does your port currently apply a system of reduced fees?
- On which criteria/waste reduction elements is this reduced fee based?
- For what type of waste is the reduction applied?
- How is the amount of the reduction calculated? Is there a relation to volumes?
- Is your port currently developing a system of reduced fees within the framework of the new Directive Art. 8(5)(b) of Directive 2019/883/EU?
- If so, on which criteria/waste reduction elements will this reduced fee be based?

C.3.4 Questions regarding the possible criteria for the implementation of reduced fees

- Which criteria would you consider to be required for the ship to be able to demonstrate that it produces reduced quantities of waste and manages its waste in a sustainable and environmentally sound manner?
  - regarding the ship's design;
  - regarding the ship's equipment and usage;
  - regarding the ship's operation;
  - regarding the sustainable and environmentally sound management.
- Are there any of above items (ship's design, equipment, operation and environmental management) which outweighs the other items?
- Are there other (besides ISO 14001/2015 and ISO 21070) existing (commercial) certification schemes known that include a useful waste management indicator?

C.3.5 Questions regarding the identification of possible criteria for reduction of waste fees

Which of the possible measures would you consider to be practically quantifiable and measurable, in order to be applicable as criteria for reducing waste fees (multiple answers):

Regarding MARPOL, Annex I:

- Use of alternative fuels (e.g. LNG) yes ☐ no ☐
- Hybrid-electric propulsion yes ☐ no ☐
- Energy efficient ship design (e.g. very good attained EEDI) to produce less oily waste yes ☐ no ☐
- Use of onshore power supply yes ☐ no ☐
- Use of oil treatment equipment yes ☐ no ☐
- Use of kites/wind propulsion to produce less oily waste yes ☐ no ☐
- Use of incinerator/gasification device to treat oily waste yes ☐ no ☐
- Other, please specify

Regarding MARPOL, Annex II

- A pipe and pump system with max. 75 l retained residue yes ☐ no ☐
- Other, please Specify

Regarding MARPOL, Annex IV

- Use of sewage treatment systems also where not required yes ☐ no ☐
- Other, please specify

Regarding MARPOL, Annex V

- Food waste digesters yes ☐ no ☐
- Use of garbage treatment/minimization equipment:
- Compactors yes ☐ no ☐
- Shredders yes ☐ no ☐
- On-board waste segregation yes ☐ no ☐
- On-board recycling/reuse yes ☐ no ☐
- Avoiding single-use plastics yes ☐ no ☐
- The use of bulk packaging yes ☐ no ☐
- Ensured segregated delivery in port yes ☐ no ☐
- Use of incinerator/gasification device to treat garbage yes ☐ no ☐

Regarding MARPOL, Annex VI

- Closed loop or hybrid scrubbers yes ☐ no ☐
- Other, please specify

Regarding operational and management systems

- Certified waste management index yes ☐ no ☐
- All ship's waste is delivered in ports with a high quality downstream yes ☐ no ☐
- Recycling KPIs yes ☐ no ☐
- Extensive data/record keeping regarding waste production yes ☐ no ☐
- Other; please specify

C.3.6 Questions regarding the waste fee reduction within the framework of the new Directive Art. 8(5)(b) of Directive 2019/883/EU

- On which part of the current cost recovery system for waste would you apply a reduction? (Direct fees, indirect fee, other?)
- In what order of magnitude should the waste fee reduction be in relation to the current waste fees?
- Would your port differentiate the delivery fee for "for reduced waste"? (Depending on size, type of frequency of the ship calling your port.)

C.4 Questionnaire for experts on technology

C.4.1 Introduction

Thank you for agreeing on being interviewed. This interview is part of a study commissioned by DG Move for the identification of criteria for determining that a ship meets the requirements for design, equipment and operation in order to demonstrate that the ship produces reduced quantity of waste and manages its waste in a sustainable and environmentally sound manner, with a view to being able to qualify for reduced fees for delivery of waste in accordance with Article 8(5)(b) of Directive 2019/883/EU on port reception facilities and the delivery of waste from ships.

The main tasks of this study are:

1. To identify the ship design specifics that are directly related to reduced production of waste and attribute to on-board waste management.
2. To produce an inventory of available technologies in the market as well prototypes that directly or indirectly reduce waste and/or improve on-board waste management.
3. To identify relevant operational practices and environmental management systems which results in reduced waste production and improve waste management on-board.

Ship Generated Waste (SGW) consists in the scope of our study MARPOL Annexes I, II, IV, V and VI waste with the exception of cargo residues.

C.4.2 Use of the information and confidentiality

- We will make notes of this interview that we will ask you to comment on in order to ensure our notes are accurate.
- The notes of the interviews will be used to develop proposals for criteria.
- The level of confidentiality will be your choice. The options are:
  - the notes are attached to the consultation report together with your name and your

company's name;
- the notes are attached to the consultation report together with a general indication of the type of stakeholder your company belongs to (e.g. shipyard, marine equipment supplier, port authority, waste handler, et cetera), and your company:
  - is listed as one of the interviewees;
  - is not listed as one of the interviewees.

C.4.3 Overview used technology/equipment for prevention or reduction of waste on-board ships

- Which technology/equipment is used on-board ships for waste prevention and/or reduction besides the ones on the following list? (with regard to prevention – minimalization – reuse – recycling-treatment – disposal)

Common types of Equipment for which sufficient information is available
Oily water separator
Incinerator
Sewage treatment system
Compactors
Crushers
Shredders
Comminuters
Grinders/Food pulpers
Pulpers

- Are there other innovative technology/equipment known to you? And in which market phase are they (R&D, prototypes, demonstration, market introduction, scaling)?
- Which technologies are most attractive from a cost-benefit perspective and why?
- What is according to you the best practices to reduce waste generation and disposal? Please, distinguish between oil/oily waste (Marpol Annex I), wash water residues (annex II), sewage (Annex IV), garbage (Annex V) and waste generated due to the prevention of air pollution (Annex VI).

C.4.4 Questions regarding the possible criteria for the implementation of reduced fees

- Which criteria would you consider to be required for the ship to be able to demonstrate that it produces reduced quantities of waste and manages its waste in a sustainable and environmentally sound manner?
  - regarding the ship's design;
  - regarding the ship's equipment and usage;
  - regarding the ship's operation;
  - regarding the sustainable and environmentally sound management.
- Are there any of above items (ship's design, equipment, operation and environmental management) which outweighs the other items?

C.4.5 Questions regarding the identification of possible criteria for reducing waste fees

Which of the possible measures would you consider to be practically quantifiable and measurable, in order to be applicable as criteria for reducing waste fees " (multiple answers):

Regarding MARPOL, Annex I

- Use of alternative fuels (e.g. LNG) yes ☐ no ☐
- Hybrid-electric propulsion yes ☐ no ☐
- Energy efficient ship design (e.g. very good attained EEDI) to produce less oily waste yes ☐ no ☐
- Use of onshore power supply yes ☐ no ☐
- Use of oil treatment equipment yes ☐ no ☐
- Use of kites/ wind propulsion to produce less oily waste yes ☐ no ☐
- Use of incinerator/gasification device to treat oily waste yes ☐ no ☐
- Other, please specify

Regarding MARPOL, Annex II

- A pipe and pump system with max. 75 l retained residue yes ☐ no ☐
- Other, please Specify

Regarding MARPOL, Annex IV

- Use of sewage treatment systems also where not required yes ☐ no ☐
- Other, please specify

Regarding MARPOL, Annex V

- Food waste digesters yes ☐ no ☐
- Use of garbage treatment/minimization equipment:
- Compactors yes ☐ no ☐
- Shredders yes ☐ no ☐
- On-board waste segregation yes ☐ no ☐
- On-board recycling/reuse yes ☐ no ☐
- Avoiding single-use plastics yes ☐ no ☐
- The use of bulk packaging yes ☐ no ☐
- Ensured segregated delivery in port yes ☐ no ☐
- Use of incinerator/gasification device to treat garbage yes ☐ no ☐

Regarding MARPOL, Annex VI

- Closed loop or hybrid scrubbers yes ☐ no ☐
- Other, please specify

Regarding operational and management systems

- Certified waste management index yes ☐ no ☐
- All ship waste is delivered in ports with a high quality downstream treatment yes ☐ no ☐
- Recycling KPIs yes ☐ no ☐
- Extensive data/record keeping regarding waste production yes ☐ no ☐
- Other, please specify

C.5 Questionnaire for marine equipment providers

C.5.1 Introduction

Thank you for agreeing on being interviewed. This interview is part of a study commissioned by DG Move for the identification of criteria for determining that a ship meets the requirements for design, equipment and operation in order to demonstrate that the

ship produces reduced quantity of waste and manages its waste in a sustainable and environmentally sound manner, with a view to being able to qualify for reduced fees for delivery of waste in accordance with Article 8(5)(b) of Directive 2019/883/EU on port reception facilities and the delivery of waste from ships.

The main tasks of this study are:

1. To identify the ship design specifics that are directly related to reduced production of waste and attribute to on-board waste management.
2. To produce an inventory of available technologies in the market as well prototypes that directly or indirectly reduce waste and/or improve on-board waste management.
3. To identify relevant operational practices and environmental management systems which results in reduced waste production and improve waste management on-board.

Ship Generated Waste (SGW) consists in the scope of our study MARPOL Annexes I, II, IV, V and VI waste with the exception of cargo residues.

C.5.2 Use of the information and confidentiality

- We will make notes of this interview that we will ask you to comment on in order to ensure our notes are accurate.
- The notes of the interviews will be used to develop proposals for criteria.
- The level of confidentiality will be your choice. The options are:
  - the notes are attached to the consultation report together with your name and your company's name;
  - the notes are attached to the consultation report together with a general indication of the type of stakeholder your company belongs to (e.g. shipyard, marine equipment supplier, port authority, waste handler, et cetera), and your company:
    - is listed as one of the interviewees;
    - is not listed as one of the interviewees.

C.5.3 Questions on specific equipment/technology (used, in development and/or tested) for reducing waste

- Which technology/equipment for the prevention and/or reduction of waste on-board ship has been developed by your company?
- What is the Technology Readiness Level? (proto-type/pilot/market demonstration/introduction phase?)
- Is this technology/equipment already widely used?
- For what types of ships can this technology be used? (type/GT, etc.)
- Which type of waste can be treated with this technology/equipment? Could you briefly explain the purpose of the method?
- Are there specific requirements on-board for this technology or when the waste is handled at the port?
- To which end is the waste handled with this technology (recycling, reuse, discharging)?
- What is the reduction rate of such technology/equipment?
- What quantities of waste are/can be handled per time period?
- What are the costs of this technology and or payback period? (In case on newly build ship/retrofit.)
- Can you provide a Life Cycle analysis for this technology/Equipment?

C.5.4 Questions on choices made for the use of the equipment/technology (if applicable)

- Could you provide us with details of specific ships that are using such technology?
- To which regulatory framework does this technology/equipment provide compliance? Or does it go beyond the level of Compliance?
- Is your waste management technology comparable with other technologies for ships within the same type of ship waste category? If yes, which aspects of your technology are comparable with other technologies and what makes your technology unique?
- Different ship types and ship sizes produce different type and quantities of waste. What are the important criteria to select your on-board treatment technology?
- What are the criteria for the use of the technologies on-board ships? (Cost, technical, operational, regulatory, other?)
- Do these criteria differ among ship types?

C.6 Questionnaire for classification societies

C.6.1 Introduction

Thank you for agreeing on being interviewed. This interview is part of a study commissioned by DG Move for the identification of criteria for determining that a ship meets the requirements for design, equipment and operation in order to demonstrate that the ship produces reduced quantity of waste and manages its waste in a sustainable and environmentally sound manner, with a view to being able to qualify for reduced fees for delivery of waste in accordance with Article 8(5)(b) of Directive 2019/883/EU on port reception facilities and the delivery of waste from ships.

The main tasks of this study are:

1. To identify the ship design specifics that are directly related to reduced production of waste and attribute to on-board waste management.
2. To produce an inventory of available technologies in the market as well prototypes that directly or indirectly reduce waste and/or improve on-board waste management.
3. To identify relevant operational practices and environmental management systems which results in reduced waste production and improve waste management on-board.

Ship Generated Waste (SGW) consists in the scope of our study MARPOL Annexes I, II, VI,V and VI waste with the exception of cargo residues.

C.6.2 Use of the information and confidentiality

- We will make notes of this interview that we will ask you to comment on in order to ensure our notes are accurate.
- The notes of the interviews will be used to develop proposals for criteria.
- The level of confidentiality will be your choice. The options are:
  - the notes are attached to the consultation report together with your name and your company's name;
  - the notes are attached to the consultation report together with a general indication of the type of stakeholder your company belongs to (e.g. shipyard, marine equipment supplier, port authority, waste handler, et cetera), and your company:
    - is listed as one of the interviewees;
    - is not listed as one of the interviewees.

C.6.3 Questions regarding the general aspects of the certification scheme

- Are there certification requirements for waste elements in the scheme that your organization verify?
- Which certification scheme, what is the background and when were the waste elements put in place?
- What differs this certification scheme with other comparable environmental schemes for the shipping industry?
- For which seagoing vessel are applicable (type/size)?
- Which type of ship are currently certified within this scheme?
- How many ships are certified and at which level?

C.6.4 Questions regarding relevance of waste elements

- How does the system of compliance and or score works?
- What is relevance of waste elements in comparison to other parts of the scheme? Can a ship be certified without compliance to the waste elements? Is it also possible to rate the ship only on waste elements?
- How many ships are certified were waste elements count as is a significant part?
- What are the specific waste elements in the scheme?
- When verifying an equipment, are elements as use and maintenance evaluated?

C.6.5 Questions regarding benefits of the scheme

- Which benefits are there for the ships to choose for this scheme?
- Which organizations are incentive providers?
- Are among the incentive providers ports? How many in total and how many EU-ports?
- What kind of incentives are provided by ports? Which ports? Could you provide an overview?

C.6.6 Questions regarding verification of criteria that demonstrates that a ship produces reduced amount of waste?

- What would you consider as a condition to set such criteria in place?
- What elements should it contain that are measurable and quantifiable?
- What are your views on the way it should be verified by ports?

D Background survey participants

The internet survey was conducted between July and September 2020 for shipowners and European Ports. The questionnaire for ports and shipping companies was used and specified to fit the survey tool. The surveys were distributed to ports and shipping companies via the European Sea Ports Organization (ESPO), the European Community Shipowners' Associations (ECSA) and the European Port Forum (EPF). 20 ports and 21 shipping companies completed the surveys.

21 shipping companies completed the survey. Except for one shipping company, all these shipping companies are positioned in Europe. However, this does not mean that their ships only operate in Europe. These 21 shipping companies have together in total 594 ships in their fleet. These ships are subdivided per ship type and ship size in **Table 15**. Almost all ship types and sizes are represented in the survey. The largest cruise ships, tankers, container and Ro-Ro ships have the largest share of ships. No shipping company who participated in the survey have fishing vessels in her fleet. All information in the report regarding fishing vessels is therefore obtained from interviews.

Table 15 - Subdivision of the total number of ships from the shipping companies who participated in the survey

	<400 GT	400 – 4,999 GT	5,000 – 9,999 GT	10,000 – 14,999 GT	15,000 – 19,999 GT	20,000 – 24,999 GT	25,000 – 29,999 GT	30,000 – 69,999 GT	>70,000 GT	Total
Dry bulk carriers	0	0	0	0	0	1	0	9	1	**11**
Tankers	0	8	3	5	14	4	37	35	46	**152**
Container and RoRo ships	0	0	7	9	32	5	22	30	34	**139**
General cargo ships	0	4	0	4	0	2	2	0	0	**12**
Ferry and Ro-Pax ships	12	14	6	0	1	0	0	8	0	**41**
Fishing vessels	0	0	0	0	0	0	0	0	0	**0**
Cruise ships	0	1	0	0	0	0	1	20	176	**198**
Other	0	13	21	1	1	1	0	4	0	**41**
Total	**12**	**40**	**37**	**19**	**48**	**13**	**62**	**106**	**257**	**594**

20 ports completed the survey, which are all located in Europe. A subdivision of the number of ports per region is provided in **Table 16**. The largest share of ports who participated in the survey are located in West-Europe and the smallest share of ports are located in East Europe. The share of ports located in North Europe and South Europe are equal.

Table 16 - Amount of ports who participated in the survey divided per region in Europe

Region	Number of ports
North Europe/Baltic area	5
South Europe	5
West Europe	8
East Europe	2
Total	**20**

E Mandatory equipment requirements

Table 17 - Overview of mandatory equipment requirements based on the MARPOL Convention and its Annexes

MARPOL	Mandatory equipment requirements
Annex I liquid oily waste	Ships <400 GT: The ship is provided with: the approved oil filtering equipment required by regulation 14.1 (as for ships of 400 gross tonnage and above) and a sludge tank of sufficient capacity for the ship's operational needs; or a holding tank to retain on-board oily mixtures and oil residues, and save-alls or gutters around oil appliances. The holding tank should be of adequate capacity for the ship's operational needs and should be provided with means for transferring the contents of the tank to shore reception facilities.
	Ships >400 GT but <10,000 GT: Oil filtering equipment: any oily mixture discharged into the sea after passing the filtering equipment has an oil content not exceeding 15 ppm (regulations 14.1 and 14.6).
	Ships >10,000 GT: Ships of 10,000 gross tonnage and over require 15 ppm oil filtering equipment with alarm and automatic stopping device (regulation 14.2 and 14.7).
	Ships which are stationary (hotel ships, storage vessels, etc.) do not need to be provided with oil filtering equipment but shall be provided with a holding tank adequate for the total retention on-board of all oily bilge water (regulation 14.3).
	More information related to the provision of oil filtering equipment is provided in the revised Guidelines and specifications for pollution prevention equipment for machinery space bilges from ships (Resolution MEPC.107(49) of 18 July 2003).
Annex I solid oily waste	See MARPOL Annex V
Annex II	According to Regulation 11 of Annex II ships that are constructed on or after 1 July 1986 (for older ships some exemptions apply) and certified to carry noxious liquid substances in bulk, are to comply with chapter 17 of the International Bulk Chemical Code regarding the design, construction, equipment and operation of ships, in order to minimize the uncontrolled discharge into the sea of such substances. For ships other than chemical tankers or liquefied gas carriers certified to carry noxious liquid substances in bulk identified in chapter 17 of the International Bulk Chemical Code, the Administration shall establish appropriate measures based on the Guidelines (reference is made to resolutions A.673(16) and MEPC.148(54)) developed by the IMO in order to ensure that the provisions shall be such as to minimize the uncontrolled discharge into the sea of such substances. Regulation 12 contains requirements regarding pumping and piping arrangements, in order to ensure that tanks do not retain a certain quantity (depending on the construction date of the ship and the category of the noxious liquid substance) of residue in the tank and its associated piping. Regulation 12 also contains requirements regarding underwater discharge outlets. And although Annex II does not require the fitting of dedicated slop tanks, slop tanks may be needed for certain washing procedures. Cargo tanks may be used as slop tanks.
Annex IV sewage	Ships to which this Annex applies (regulation 2): 1. New ships >400 GT. 2. New ships of less than 400 gross tonnage which are certified to carry more than 15 persons. 3. Existing ships of 400 gross tonnage and above, five years after the date of entry into force of this Annex. 4. Existing ships of less than 400 gross tonnage which are certified to carry more than 15 persons, five years after the date of entry into force of this Annex.

MARPOL	Mandatory equipment requirements
	These ships are to be equipped with (regulation 9): – a sewage treatment plant which shall be of a type approved by the Administration, taking into account the standards and test methods developed by the IMO; or – a sewage comminuting and disinfecting system approved by the Administration. Such system shall be fitted with facilities to the satisfaction of the Administration, for the temporary storage of sewage when the ship is less than 3 nautical miles from the nearest land: or – a holding tank of the capacity to the satisfaction of the Administration for the retention of all sewage, having regard to the operation of the ship, the number of persons on-board and other relevant factors. The holding tank shall be constructed to the satisfaction of the Administration and shall have a means to indicate visually the amount of its contents.
Annex V non-hazardous garbage	MARPOL Annex V does not contain specific requirements for on-board garbage handling equipment. The MARPOL Annex V does contain discharge requirements, requirements related to the provision of PRF, and references to the provision of placards, ship garbage management plans and on-board garbage record keeping. However, some information regarding garbage management and garbage handling equipment can be found in the 2017 Guidelines for the implementation of MARPOL Annex V (Resolution MEPC.295(71) of 7 July 2017). In these guidelines reference is made to: Waste minimization (section 2.1); Shipboard garbage handling (section 2.3); Collection (section 2.4); Processing (section 2.5); Storage (section 2.6); Discharge (section 2.7); Grinding or comminution (section 2.9); Compaction (section 2.10); Incineration (section 2.11); Treatment of animal carcasses (section 2.12). Also in section 4 on Training, Education and Information reference is made to the use of on-board equipment. Although not legally binding, some of the sections in these guidelines provide practical guidance for the use of garbage handling equipment: Compliance with MARPOL Annex V involves personnel, equipment and procedures for collecting, sorting, processing, storing, recycling, reusing and discharging garbage. Economic and procedural considerations associated with these activities include storage space requirements, sanitation, equipment and personnel costs and in port garbage service charges (paragraph 2.3.2). Depending on factors such as the type of ship, area of operation, number of crew or passengers, etc., ships may be equipped with incinerators, compactors, comminuters or other devices for shipboard garbage processing. Appropriate members of the crew should be trained and assigned responsibility for operating this equipment on a schedule commensurate with ship needs. In selecting appropriate processing procedures, the following should be considered (paragraph 2.5.1). Section 2.6 on Storage: Garbage collected throughout the ship should be delivered to designated processing or storage locations. Garbage that must be returned to port for discharge at port reception facilities may require storage until arrangements can be made to discharge it ashore for appropriate processing. In all cases, garbage should be stored in a manner which avoids health and safety hazards. The following points should be considered when selecting procedures for storing garbage: .1 sufficient storage space and equipment (e.g. cans, drums, bags or other containers) should be provided. Where storage space is limited, ship operators are encouraged to consider the installation of compactors or incinerators. To the extent possible, all processed and unprocessed garbage stored for any length of time should be in tight,

MARPOL	Mandatory equipment requirements
	securely covered containers in order to prevent the unintentional discharge of stored garbage; Section 2.8 on Shipboard equipment for processing garbage: The choice of options for garbage processing depends largely upon personnel limitations, generation rate, capacity, ship configuration, voyage route and availability of port reception facilities. The type of equipment available for shipboard garbage handling includes incinerators, compactors, comminuters and their associated hardware. Section 2.9 on Grinding or comminution: The discharge of comminuted food wastes may be permitted under regulations 4.1.1 and 6.1.1 of MARPOL Annex V or paragraph 5.2.1 of part II-A of the Polar Code whilst the ship is en route. Such comminuted or ground food wastes must be capable of passing through a screen with openings no greater than 25 mm. Section 2.10 on Compaction: Most garbage can be compacted to some degree; the exceptions include unground plastics, fibre and paperboard, bulky cargo containers and thick metal items. Pressurized containers should not be compacted or shredded without the use of specialized equipment designed for this purpose because they present an explosion hazard in standard compactors (paragraph 2.10.1). 2.10.5 A compactor should be installed in a compartment with adequate room for operating and maintaining the unit and storing garbage to be processed. The compartment should be located adjacent to the areas of food processing and commissary storerooms. If not already required by regulation, it is recommended that the space should have freshwater wash down service, coamings, deck drains, adequate ventilation and hand or automatic fixed fire-fighting equipment (paragraph 2.10.5). Section 2.11 on Incinerators: Paragraph 2.11.2: Incineration conducted in a shipboard incinerator can significantly reduce the need to store garbage on-board the ship. Shipboard incinerators should be designed, constructed, operated and maintained in accordance with the 2014 Standard specification for shipboard incinerators (resolution MEPC.244(66), as amended). MARPOL Annex VI requires shipboard incinerators installed after 1 January 2000 to be type-approved and meeting specific air pollution criteria. Incinerators should only be used to incinerate materials that are specified by the incinerator manufacturer. Paragraph 2.11.5: Some of the disadvantages of incinerators may include the possible hazardous nature of the ash or vapour, dirty operation, excessive labour required for charging, stoking and ash removal. Some incinerators may not be able to meet air pollution regulations imposed in some ports and harbours or by flag and coastal States when such matters are subject to their jurisdiction. Some of these disadvantages can be remedied by automatic equipment for charging and stoking, however, the additional equipment to perform automatic functions will require more installation space. Paragraph 2.11.6: The incineration of garbage that contains a large amount of plastic involves very specific incinerator settings such as higher oxygen injection and higher temperatures (850 to 1,200°C). If these special conditions are not met, depending on the type of plastic and conditions of combustion, some toxic gases can be generated in the exhaust stream, including vaporized hydrochloric (HCl) and hydrocyanic (HCN) acids. These and other intermediary products of combustion of waste containing plastics are toxic to humans and marine life. Section 2.12 on Treatment of animal carcasses: Paragraph 2.12.7: Animal carcasses should be split or otherwise treated prior to their discharge into the sea. Procedures for the treatment of carcasses should take into account the health and safety of the crew and other livestock cargo. Treatment should facilitate the sinking or dispersal of the carcass when it is discharged into the sea. Paragraph 2.12.8: Treatment of a carcass involves: 1. manually slitting or cutting the carcass to the extent that the thoracic and abdominal cavities are opened; or 2. passing the carcass through equipment such as a comminuter, grinder, hogger or mincer.

MARPOL	Mandatory equipment requirements
	Section 4 on Training, Education and Information: Ship and reception facility operators should establish detailed training programmes for personnel operating and maintaining ships' garbage reception or processing equipment (Paragraph 4.8).
Annex V hazardous garbage	MARPOL Annex V does not contain specific equipment requirements for the on-board handling of hazardous garbage. The MARPOL Annex V does contain discharge requirements, requirements related to the provision of PRF, and references to the provision of placards, ship garbage management plans and on-board garbage record keeping. Also see the section above on Annex V non-hazardous waste.
Annex VI scrubber sludge	MARPOL Annex VI does not contain specific equipment requirements for the on-board handling of scrubber sludge. However, information regarding scrubber sludge handling can be found in the 2009 Guidelines for Exhaust Gas Cleaning Systems (Resolution MEPC.184(59) of 17 July 2009): 10.4 Washwater residue 10.4.1 Residues generated by the EGC unit should be delivered ashore to adequate reception facilities. Such residues should not be discharged to the sea or incinerated on-board. 10.4.2 Each ship fitted with an EGC unit should record the storage and disposal of washwater residues in an EGC log, including the date, time and location of such storage and disposal. The EGC log may form a part of an existing logbook or electronic recording system as approved by the Administration.
Annex VI: shipboard incineration	Regulation 16 of MARPOL Annex VI contains requirements to the use of shipboard incinerators: (1) Except as provided in paragraph (5), shipboard incineration shall be allowed only in a shipboard incinerator. (2) (a) Except as provided in sub-paragraph (b) of this paragraph, each incinerator installed on-board a ship on or after 1 January 2000 shall meet the requirements contained in annex IV to this Annex. Each incinerator shall be approved by the Administration taking into account the standard specifications for shipboard incinerators developed by the IMO (b) The Administration may allow exclusion from the application of sub-paragraph (a) of this paragraph to any incinerator which is installed on-board a ship before the date of entry into force of the Protocol of 1997, provided that the ship is solely engaged in voyages within waters subject to the sovereignty or jurisdiction of the State the flag of which the ship is entitled to fly. (3) Nothing in this regulation affects the prohibition in, or other requirements of, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, as amended, and the 1996 Protocol thereto. (4) Shipboard incineration of the following substances shall be prohibited: (a) Annex I, II and III cargo residues of the present Convention and related contaminated packing materials; (b) polychlorinated biphenyls (PCBs); (c) garbage, as defined in MARPOL Annex V, containing more than traces of heavy metals; and (d) refined petroleum products containing halogen compounds. (5) Shipboard incineration of sewage sludge and sludge oil generated during the normal operation of a ship may also take place in the main or auxiliary power plant or boilers, but in those cases, shall not take place inside ports, harbours and estuaries. (6) Shipboard incineration of polyvinyl chlorides (PVCs) shall be prohibited, except in shipboard incinerators for which IMO Type Approval Certificates have been issued.

MARPOL	Mandatory equipment requirements
	(7) All ships with incinerators subject to this regulation shall possess a manufacturer's operating manual which shall specify how to operate the incinerator within the limits described in paragraph (2) of annex IV to this Annex. (8) Personnel responsible for operation of any incinerator shall be trained and capable of implementing the guidance provided in the manufacturer's operating manual. (9) Monitoring of combustion flue gas outlet temperature shall be required at all times and waste shall not be fed into a continuous-feed shipboard incinerator when the temperature is below the minimum allowed temperature of 850 degrees Centigrade. For batch-loaded shipboard incinerators, the unit shall be designed so that the temperature in the combustion chamber shall reach 600 degrees Centigrade within five minutes after start-up. (10) Nothing in this regulation precludes the development, installation and operation of alternative design shipboard thermal waste treatment devices that meet or exceed the requirements of this regulation. Furthermore, also note the refence to the usage of incinerators in the 2017 Guidelines for the implementation of MARPOL Annex V (Resolution MEPC.295(71) of 7 July 2017).

F Ranking of waste reduction and minimization measures

Table 18 - Ranking of waste reduction and minimization measures by ports and shipping companies who participated in the study

Ranking of waste reduction and minimization measures		
	Ranking of the ports	**Ranking of the shipping companies**
1	Use of alternative fuels	On-board waste segregation
2	On-board waste segregation	Sewage treatment systems
3	Avoiding single use plastic	Use of alternative fuels
4	Ensured separated waste delivery in ports	Avoiding single use plastic
5	Electric propulsion	Energy efficient ship design (EEDI)
6	Energy efficient ship design (EEDI)	On-board recycling/reuse
7	On-board recycling/reuse	All waste delivered in EU ports
8	Certified waste management index	Ensured separate waste delivery in ports
9	Sewage treatment system	Compactors
10	Food waste digesters	Shore power
11	Extensive data/record keeping	Extensive date/record keeping
12	All waste delivered in EU ports	Use of bulk packaging
13	Use of bulk packaging	Electric propulsion
14	Shore power	Use of oil treatment equipment
15	Use of kites/wind propulsion	Recycling KPIs
16	Compactors	Food waste digesters
17	Shredders	Closed loop or hybrid scrubbers
18	Incinerator/gasification for garbage	Certified waste management index
19	Use of incinerator/gasification system	Shredders
20	Recycling KPIs	Use of incinerator/gasification system
21	Closed loop or hybrid scrubbers	Use of kites/wind propulsion
22	Use of oil treatment equipment	Incinerator/gasification for garbage
23	Pipe and pump system max. 75 litre	Pipe and pump system max. 75 litre

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